Annual Report 1954

LIBRARY
FEB 12 1968
ROCKY MOUNTAIN STATION

LAKE STATES FOREST EXPERIMENT STATION

ST. PAUL, MINNESOTA

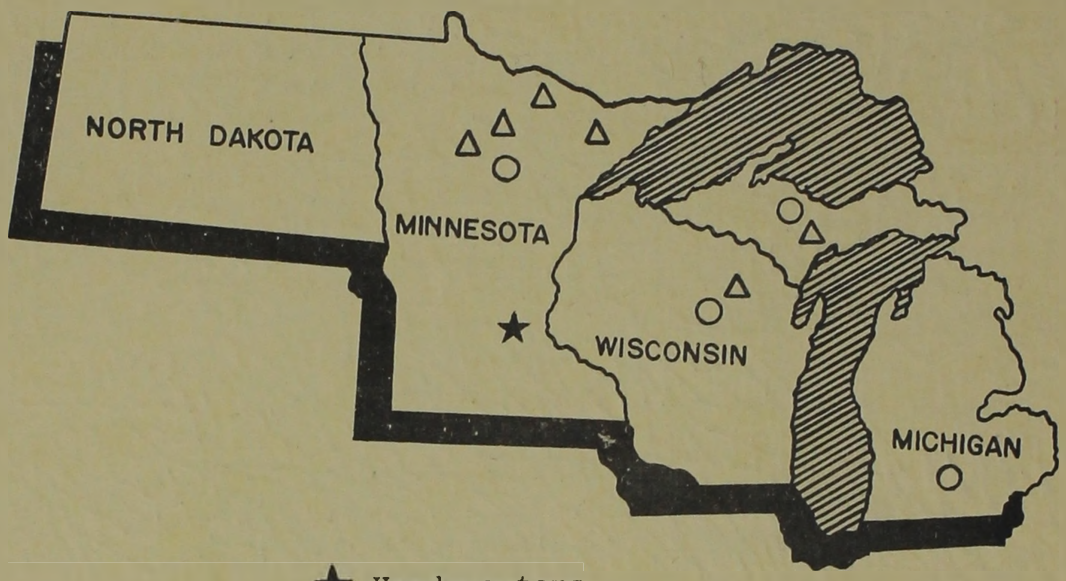
M.B. DICKERMAN, DIRECTOR

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TERRITORY SERVED BY THE

LAKE STATES FOREST EXPERIMENT STATION

ST. PAUL, MINNESOTA



★ Headquarters

○ Research Centers

△ Experimental Forests

Station Director..... M. B. Dickerman
Administrative Assistant..... Jerry Roch
Program Leaders:
- Forest Management..... R. D. McCulley
- Forest Economics..... R. N. Cunningham
- Forest Utilization..... A. W. Toole
- Forest Insects..... H. J. MacAloney
- Forest Diseases..... R. L. Anderson
- Forest Fire Research..... J. A. Mitchell
- Wildlife Research..... L. W. Krefting

Research Center Leaders:
- Headwaters, Grand Rapids, Minn. ..... Z. A. Zasada
- Northern Lakes, Rhinelander, Wis. ..... J. H. Stoeckeler
- Lower Peninsula, East Lansing, Mich. ..... J. L. Arend
- Upper Peninsula, Marquette, Mich. ..... Carl Arbogast

31ST ANNUAL REPORT OF THE

LAKE STATES FOREST EXPERIMENT STATION

For the Calendar Year 1954

The Lake States Forest Experiment Station is located on the St. Paul Campus of the University of Minnesota. It is a regional office of the United States Forest Service and is maintained in cooperation with the University of Minnesota. Through federal legislation, it is authorized to carry on forest research for the benefit of all forestry agencies in the region, including public forest services, wood-using industries, farmers, and other forest owners.

The territory in which the Station operates includes the States of Michigan, Wisconsin, Minnesota, and North Dakota. In addition, the Station is responsible for forest and insect surveys of eight central states: Ohio, Indiana, Illinois, Kentucky, Iowa, Missouri, Nebraska, and Kansas. Besides the central office in St. Paul, field offices are located at East Lansing and Marquette, Michigan; Rhinelander and Wausau, Wisconsin; and Grand Rapids, Minnesota.

Lake States Forest Experiment Station
St. Paul Campus, University of Minnesota
St. Paul 1, Minnesota

C O N T E N T S

Page

Introduction 1

Forest management 4

Forest genetics 4

Planting completed in regional jack pine seed source study . . 5
Initial measurements of pine hybrids 5
Earliness of shoot growth in young red pine seedlings as related to seed source and seed tree age 5
Plans for 1955 6

Integrated utilization and management research 6

Studies of charcoal production expanded 6
Analysis of tree quality begun 7
Program orientation under consideration 7

Hardwoods 8

Disking increases yellow birch reproduction 8
Physical factors affecting yellow birch seedling establishment 9
Installation of stocking level study completed 9
Injury to crowns of yellow birch observed 10
High seed production in second-growth northern hardwood stand 10
Thinning in 11-year-old second-growth northern hardwoods . . . 11
Supplemental deer feed produced by non-commercial thinning . . 11
Plans for 1955 11

Aspen 12

Some aspen site factor relationships discovered 12
Costs of improving a bigtooth aspen stand with chemical herbicides 12
Plans for 1955 13

Pine management 13

Red pine stands show rapid growth rates 13
Mechanical thinning in young jack pine stands 13
Plans for 1955 14

Swamp conifer types 14

Reproduction cutting in mature swamp spruce 14
Growth of 75-year-old black spruce after first pulpwood thinning 15

Page

Eliminating brush competition in deforested conifer swamps . . 15
Plans for 1955 16

Balsam fir 16

Plans for 1955 16

Plantation management 16

Soil moisture and snow accumulation in a red pine plantation . 16
Pruning tests 17
Plans for 1955 17

Nursery research 18

Chemical herbicides in forest management 18

Tolerance of conifers to 2,4-D and 2,4,5-T high after August 1 18
Summer and fall months best time for chemical frill girdling . 19
Plans for 1955 19

Farm forestry studies 20

Cooperation with the University of Minnesota 20
Timber harvest forest production 21
Regeneration of oak woodlots 21
Plans for 1955 22

Mensuration 22

Composite volume tables soon to be available 22
More efficient techniques for estimating growth being sought . 22
A test of Bitterlich's point sampling method 22

Forest protection 23

Forest fire research 23

30 years of progress in fire protection 23
The fire research effort 25
Suggestions for the future 26

Forest insects 26

Larch sawfly research expanded as epidemic continues 27
Plans for 1955 27
Pine sawflies are increasing in importance 29
Plans for 1955 29
The spruce budworm returns 29
Plans for 1955 30

Page

The jack-pine budworm threatens Lake States jack pine stands . 31
Plans for 1955 31
Saratoga spittlebug still a plantation problem 31
Plans for 1955 32
The European pine shoot moth a menace in lower Michigan . . . 32
Plans for 1955 32
Miscellaneous surveys 33

Forest diseases 33

Factors influencing the incidence of Hypoxylon canker of aspen 33
Plans for 1955 34
Races of white pine blister rust 34
Plans for 1955 35
Oak wilt survey 35
White pine root rot 35
Defect in northern hardwoods 36
Red pine twig injury 36
Black spruce dwarf mistletoe 36
Other research needed 37

Forest wildlife research 37

Effect of white-tailed deer and snowshoe hares on range recovery 38
Results of controlled deer hunts on the Mud Lake National Wildlife Refuge 38
Deer range appraisal on the Necedah and Tamarac National Wildlife Refuges 39
Effect of mammals on yellow birch seedlings 40
Other research projects 41
Plans for 1955 41

Forest economics 41

Forest Survey 41

Forest statistics for Minnesota published 43
Survey moves along in other states 44
Timber cutting studies a part of forest survey 45
Keeping the survey up to date 47

Industry analysis 47

Marketing research 48

Twin Cities hardwood market study under way 48
Major marketing problems concern low-grade hardwoods 48

Publications in 1954: arranged by subject matter 49

LAKE STATES FOREST EXPERIMENT STATION

ANNUAL REPORT FOR 1954

INTRODUCTION

In our annual report for 1953, we pointed out that the great changes occurring during the past 30 years in the composition of our Lake States forests as well as in the general economy of the region require both an expansion of forest research and a change in its emphasis. Special concern was expressed over the lack of genetics and utilization programs. This year we can report progress in both fields. In 1954, funds were made available for placing greater emphasis on forest genetics, utilization, insect, and marketing research. Through this broader and more balanced program, the Station should now be able to make a much larger contribution to the solving of forest problems in the Lake States region.

That the forest resources of the Lake States have been changing rapidly during recent decades is evident, even to the casual observer. Largely because of improved management practices and a highly effective fire detection and control system, young growth has become established on millions of acres of cut-over or burned-over land, and second-growth forests are thickening up and reaching merchantable size in increasing numbers. Unfortunately, according to Forest Survey reports and special studies, not all the changes are for the better. For areas where current data are available to compare with the survey data for the 1930's, the average size of sawtimber trees is decreasing, and the average quality is poorer. Furthermore, the proportion of the less desirable species is increasing, and large areas of poorly stocked timber remain.

The efforts in recent years by both private industry and public agencies to put their lands on a sustained-yield basis point to the need for increased research. Good management of forest lands requires, among other things, thinnings in young stands, better utilization of tops and limbs, and removal of cull trees and inferior species and their replacement with seedlings that will produce high-quality trees. To make this economically feasible, improved logging and milling methods and equipment are required, and markets for poor-quality material must be found. Thus management and utilization go hand in hand; researchers in both fields must cooperate closely on the problems that need to be solved.

This need was recognized in 1954 by an appropriation of funds for management-utilization research. A new program is now being developed by the Station placing emphasis on forest utilization problems associated with the management of hardwoods. Mr. Arlie W. Toole, a specialist in the field, is heading up the program. A centrally located field office was set up at Wausau, Wisconsin, with a technically trained staff. Through this field office forest utilization phases of research will be emphasized.

Responsibility for conducting surveys of existing markets for low-grade material, examining opportunities for local industries, and carrying on other marketing research, has been assigned to the Division of Economics. The possibilities in the pallet industry are already being studied.

Research in the protection of our forests from the depredations of fire, insects, disease, and certain wildlife species is an important phase of the Station's work. Thus standing timber is conserved, and the seedlings that will form our future forests are saved from destruction. Studies are also made to improve the wildlife habitat and to produce maximum populations consistent with other forest uses.

In 1955, research in forest insects will be considerably augmented. The spruce budworm which has recently been reported in increasing abundance in Michigan and Minnesota will be the subject of new studies. Greater emphasis will be placed on new techniques for making forest insect surveys, and studies already underway will be expanded.

Studies of major disease problems such as Hypoxylon canker in aspen, white pine blister rust, and defect in northern hardwoods were continued this year. With the small staff available for this field of forest research, no increase in disease research activities is contemplated at this time.

Although genetics is newly established this year as a formal regional program, a few seed source studies were begun as long as 25 years ago when large-scale planting operations concentrated attention on the need for seed which would produce hardy, high-quality trees. During the intervening years a few additional studies were initiated with the help of industry, university, and state organizations. The inauguration of an expanded genetics program at the Station will enable us to carry forward vigorously research to improve the condition of our forests through such studies as selection and breeding for vigor, rapid growth, quality wood, and resistance to disease.

Accurate knowledge on the distribution and composition of our forests, the amount and quality of the timber, and the rate of growth, cutting, and mortality are essential to sound economic development. This is the contribution made by the forest survey conducted by the Station in cooperation with other public and private agencies and organizations. In order to effect economies in over-all planning and administration, the forest survey work previously carried on by the Central States Forest Experiment Station was transferred to St. Paul this year. Consequently the Lake States Station is now responsible for forest surveys not only in the three Lake States and North Dakota, but also in Ohio, Indiana, Illinois, Kentucky, Iowa, Missouri, Nebraska, and Kansas.

Since the establishment of the Lake States Station in 1923, our research in fire prevention, detection, and control has been conducted primarily by John A. Mitchell. Mr. Mitchell retired on December 31 after over 45 productive years in the Forest Service. Some idea of the great advances that have been made in fire research in the Lake States area during the

past 30 years is given in this report. Although much work still remains to be done, particularly in regard to prevention and control of fires under acute burning conditions, and intensive protection efforts must be continued, some attention should now be given to the effects of fire and its uses as a tool in forest-land management.

The achievements attained in the field of forest-fire control in the Lake States is a notable example of the advantages of close cooperation among all research groups and forest-land owners and managers. In other forest research fields as well, the success of much of the Station's program is in a large part dependent on such cooperation. As in previous years, much of the forest survey work has been done by such agencies as the Iron Range Resources and Rehabilitation Commission in Minnesota, the state conservation departments, the national forests, and county and industrial organizations. Help has also been received on numerous projects in other forest research fields.

In addition to continuing agreements carried over from previous years, several new cooperative agreements have been made. These concern: (1) two management studies with the Iron Range Resources and Rehabilitation Commission, (2) a shelterbelt study and an investigation into the uses of low-grade hardwood material with the University of Minnesota, (3) a paper birch-site study with the Nekoosa-Edwards and Rhinelander Paper Companies, the National Container, Kimberly-Clark, and Marathon Corporations, Mosinee Paper Mills Company, and Consolidated Water Power and Paper Company, (4) the planning and operation of a charcoal kiln with the Cliffs Dow Chemical Company, (5) a second charcoal kiln study with St. John's University, the University of Minnesota, Forest Products Laboratory, and the Iron Range Resources and Rehabilitation Commission, and (6) the use of an area owned by the Kimball Sanatorium in lower Michigan for management studies.

To summarize, forest surveys provide us with basic data for estimating research needs; fire, insect, and disease studies form the basis for protection efforts; and management, genetics, utilization, and economic research are directed toward the greatest production and most economic uses of our forests. The picture is still not complete, for with the ever-increasing industrial and population demands for water, the need for studies of forest-water relationships also increases. With programs developed in 1954, however, the Lake States Station, along with other research groups, is in a far better position than ever before to provide industry and the people of the area with the information and research services so urgently needed in the region.

The following pages discuss briefly major current projects and present some of the findings. Mention is also made of our plans for 1955 and of major problems which need to be investigated. A complete list of Station publications in 1954 is included.

FOREST MANAGEMENT

Of greatest general interest in the field of management is the establishment of a forest genetics project and initiation of an integrated hardwood utilization-management program. As a result of these new projects, some of the men already on the staff have been reassigned and several additional technicians employed. Improvement of forest stands through study of genetic relationship will be hastened with the facilities and men now available. Likewise, the beginning of utilization studies will permit more rapid advances in stand management through coordinated effort in both fields.

In both these major activities in which increased research is planned, cooperation of other organizations will be needed and encouraged. In genetics work, cooperative projects have been under way for several years with university and state organizations and industry. The Lake States Forest Tree Improvement Committee will be more important than ever in its stated purpose of "encouraging and coordinating forest genetics work in this region." Similarly, the cooperation and interest of wood-using industries, university technologists and foresters, and state foresters will be needed to help formulate a program in management-utilization which will be directed toward the most important problems in the area. Maintaining a balance between short-term and long-term research will be especially important.

Research in other phases of forest management has been pursued with undiminished vigor. Results are emphasized in the following pages; major experiments for which no conclusions are now obtainable are mentioned briefly, numerous minor ones not at all.

Forest Genetics

Since 1928 the Station has carried on intermittent work in forest tree improvement as a part of its regular forest management activities. It was not until July 1, 1954, however, that a specific project was set up at the Station. First efforts to get this newly authorized activity under way have been directed toward recruiting personnel, obtaining specialized equipment, and locating a center for field work. Despite the tremendous demand for the few available forest geneticists, brought about by the almost simultaneous expansion of forest genetics activities throughout the country, reasonable progress has been made in developing a technical staff of three men. Much of the specialized equipment has been assembled, and the rest will be available in the spring. A survey to locate a field center for genetics work has been completed, and a decision on location will be made in the near future.

Through membership in the Lake States Forest Tree Improvement Committee, the staff in genetics will coordinate its activities with the work of other agencies and assist others in carrying on genetics studies.

Planting Completed in Regional Jack Pine Seed Source Study

In the spring of 1954, about 75,000 2-0 jack pine trees of more than 30 different seed sources were lifted, counted, packed, and distributed to 11 planting sites in Wisconsin and Michigan by the Station with the cooperation of the Wisconsin Conservation Department. At the same time the University of Minnesota similarly handled about 53,000 trees which were distributed to 8 planting sites in Minnesota and western Wisconsin. Seventeen plantations, each containing 4 replications of the 30 seed sources, were established in cooperation with the Station by industrial, county, state, and university organizations. Survival has been above 80 percent for most seed lots in the majority of the plantations.

Initial Measurements of Pine Hybrids

In 1950, the Institute of Forest Genetics in California supplied small lots of seed including hybrids between lodgepole pine and jack pine and between western white and eastern white pine. The Station grew stock from this seed at Wisconsin's Hugo Sauer Nursery. The lodgepole-jack pine hybrids, along with stock of the parent species, were field-planted in each of the three Lake States in the spring of 1953. Second-year examinations, not yet thoroughly analyzed, indicate that the lodgepole pine is poorest, the jack pine best, and the hybrids intermediate in growth and survival.

Earliness of Shoot Growth in Young Red Pine Seedlings as Related to Seed Source and Seed Tree Age

In connection with a more comprehensive study, more than 160 lots of red pine seedlings grown from spring-sown seed were examined early in June of their second year in the nursery seedbeds and rated as fast, medium, or slow according to ocular estimates of the relative amount of terminal bud growth which had taken place. These seedlings represented 8 seed-collection regions and 5 broad age classes of mother tree. Results indicate a general relationship between earliness of beginning shoot growth and length of growing season of the place of seed origin, and that progeny of very old or very young trees are slower in starting terminal shoot growth than those of intermediate age.

Climbing a red pine to collect cones for a seed source study.

Plans for 1955

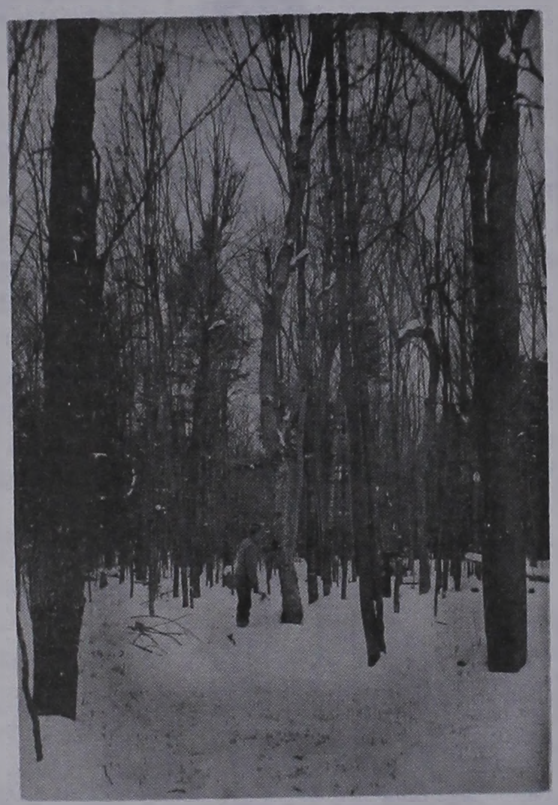
The major effort in 1955 will be to get the new forest genetics program into full swing. This will include completing recruitment of the staff, setting up a genetics field center, carrying out exploratory work to locate superior stands and trees which could supply material needed in a tree improvement program, and locating suitable outplanting sites throughout the region.

Integrated Utilization and Management Research

The integrated management-utilization forest research program is now under way at the Station. Study of hardwood problems--a research need long felt by forest-land owners and managers--will be emphasized. Closer ties between silviculturists and wood technologists are a necessity in solving the interrelated and inseparable problems of growing, harvesting, and using our wood supply. The new program will provide facilities and leadership for this work through an office at Wausau, Wisconsin. The established policy of cooperating with representatives of timber and pulpwood industries, land-managing agencies, and wood users, as well as other research agencies, will add a great deal to the effectiveness of studies undertaken in this field.

Efforts are presently being concentrated on strengthening utilization work already included in the Station's program and setting priorities on other studies under consideration.

Studies of Charcoal Production Expanded



Two yellow birch cull trees in this northern hardwood stand should be cut; they could be used for "charcoaling."

One major project under way is a study of utilizing low-grade hardwoods from thinnings and inferior species in the production of charcoal in small kilns. Cooperative research on charcoal operations in Minnesota and Michigan has been strengthened by the addition of another kiln in Wisconsin. Two 7-cord experimental kilns designed by the Forest Products Laboratory have been built.

Construction of the Minnesota kiln at St. John's University, near St. Cloud, was financed by the Iron Range Resources and Rehabilitation Commission and built by St. John's University who will operate it. Study of the operation of this kiln will be directed by the Iron Range Commission, the University

of Minnesota, the Forest Products Laboratory, and the Station working together through a committee organized for that purpose.

The second kiln has been built on the Argonne Experimental Forest in Wisconsin and will be operated by the Station with assistance from the Forest Products Laboratory.

A third kiln of 10-cord capacity, also of Laboratory design, will be operating next spring on the Upper Peninsula Experimental Forest in cooperation with the Cliffs Dow Chemical Company of Marquette, Michigan.

Analysis of Tree Quality Begun

The high values and extensive defect in old-growth northern hardwood stands have made it difficult to appraise standing timber as the basis for sale or to assure each tree's being converted to its highest use. Some study of this problem has already been made by the Station, but a major effort is required to follow through on the grade-recovery phase in the sawmill. This job has now been started in connection with studies of cutting methods at the Upper Peninsula Experimental Forest. The Schneider Bros. Lumber Company of Marquette, Michigan, is cooperating on the study.

Program Orientation Under Consideration

Of high priority is the development of a sound management-utilization program. Consideration is being given to work needed, who is best equipped to do such work and how the skills of all can best be used in the future. The Station believes greatest emphasis is needed in the field of harvesting studies and quality problems. It recognizes, though, that in such technical fields both laboratory and on-the-ground work is essential. Laboratory phases will be handled by the Forest Products Laboratory and forest schools. In this connection two projects are now being explored and others will undoubtedly come into the picture as a well balanced and productive program is sought.

1. Raw material for the fiber industry is perhaps the major potential outlet for improvement cuttings from young Lake States forests. Conversion to chips offers interesting possibilities for handling low-value trees and logging waste. Recent tests of a portable chipper at the Lower Peninsula Research Center suggest continued development in this direction. Agricultural uses might be expanded considerably. To reach the major market, the pulping industry, would take extensive research and development requiring time and a substantial investment of effort by most of the research agencies in the region.

2. Improvement cutting in oak and lowland hardwood stands in the southern part of the region produces logs of low average quality which are difficult to saw at a profit. Increasing use by the pulping industry will probably assist in moving a portion of this material. For the most part, however, the solution must come from

improved manufacture to make the best use of the logs in current markets and through the development of new markets for special grades. The initial phase would require an estimate by grade of volume in managed stands that will be available in the immediate future and on a sustained basis.

Hardwoods

Improvement in the management of hardwood stands of the region which, without the aspen type, comprise a third of the forest area of the Lake States, is vital to long-range increase of the timber supply. In the southern portion of the Station's territory the predominant forest cover is mixed oak second-growth stands in small woodlots. Because of their accessibility and control by resident owners, high levels of management are possible although poor management generally has prevailed in the past. To the north, the northern hardwoods predominate. In both these types, sprout reproduction may result in second-growth stands of poorer form and composition than the original stands. Methods of obtaining more desirable reproduction and of improving existing second-growth stands, thinning methods, and proper levels of stocking have been studied during the past year.

Although the area of old-growth northern hardwoods has been greatly reduced, remaining stands in northern Wisconsin and Michigan supply quality material for an important furniture and veneer industry in the region. A number of studies in this type are being continued, and new studies have been undertaken, to answer questions about cutting methods and regeneration.

Disking Increases Yellow Birch Reproduction

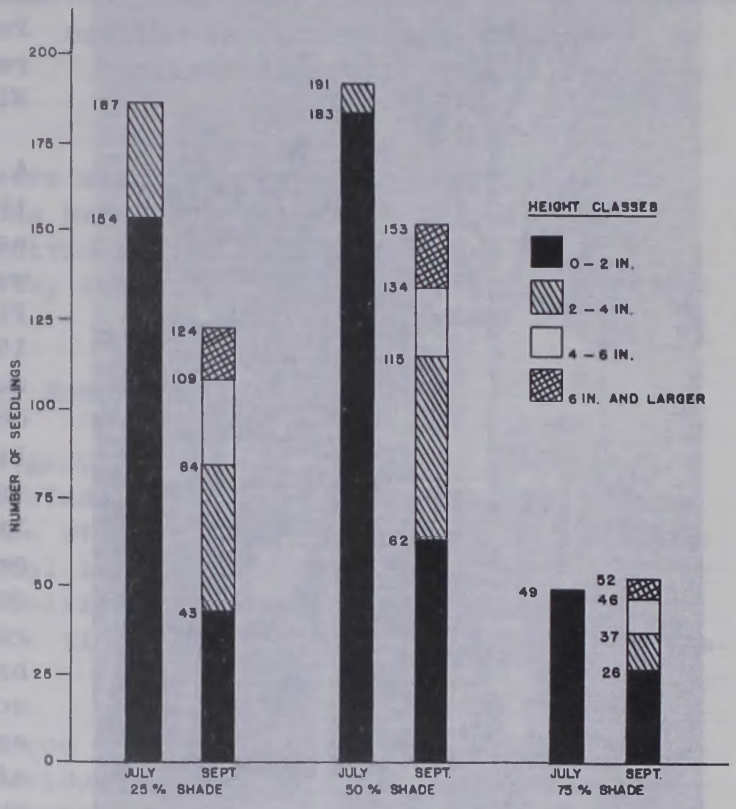
An experiment installed in 1952 showed that exposure of mineral soil with a disk-harrow increased the catch of yellow birch. A 20-acre tract of hemlock-hardwood was cut to leave a residual stand per acre of 3,000 board feet gross of yellow birch properly spaced for seed dispersal. The ground was then disked to expose four different proportions of mineral soil.

The number of 0- to 6-inch-tall yellow birch seedlings was greatly increased by all degrees of disking. The larger size classes showed varying response to the intensity of disking which caused the loss of some of the trees in these classes. Considerable mortality also occurred in the undisked area, probably as a result of sudden exposure in opening up the stand. Distribution of reproduction as indicated by the percentage of plots occupied by yellow birch reproduction was good. Unless mortality is heavy in succeeding years, it appears that disking to expose mineral soil on 25 percent of the seedbed will give good stocking of yellow birch reproduction.

Physical Factors Affecting Yellow Birch Seedling Establishment

Seedling establishment was generally well distributed over the experimental area described above, but the influence of microtopography was evident. The light, easily moved yellow birch seed was blown from the ridges into the small furrows formed in disking. Consequently, reproduction was most abundant in the furrows. In areas where standing water occurred in the spring or where the leached soil horizon was exposed there was little or no reproduction.

An exploratory study, established in late July, showed that shade had considerable effect on growth of the current year's reproduction. Lath shades, spaced to give 25, 50, and 75 percent shade over 3 x 3-foot plots, were set up in a wet area with fairly uniform seedbed conditions. Best seedling development was found under the 50 percent shade, where leaf color was good and stem and root development were excellent. The seedlings growing under 25 percent shade were generally chlorotic, similar to unshaded seedlings in the vicinity. Under 75 percent shade, leaf coloration was unusually dark green and leaf size larger than average. Stems under this much shade were of smaller size and more succulent than on the other plots; root development was generally poor. Unfortunately, deer browsed some of the seedlings on the plots with 25 percent shade, destroying to some extent the comparability of the plots. Height growth was somewhat better under 50 percent shade than under 75 percent shade.



Number of yellow birch seedlings per 3 x 3-foot plot during the first growing season, under three degrees of shade.

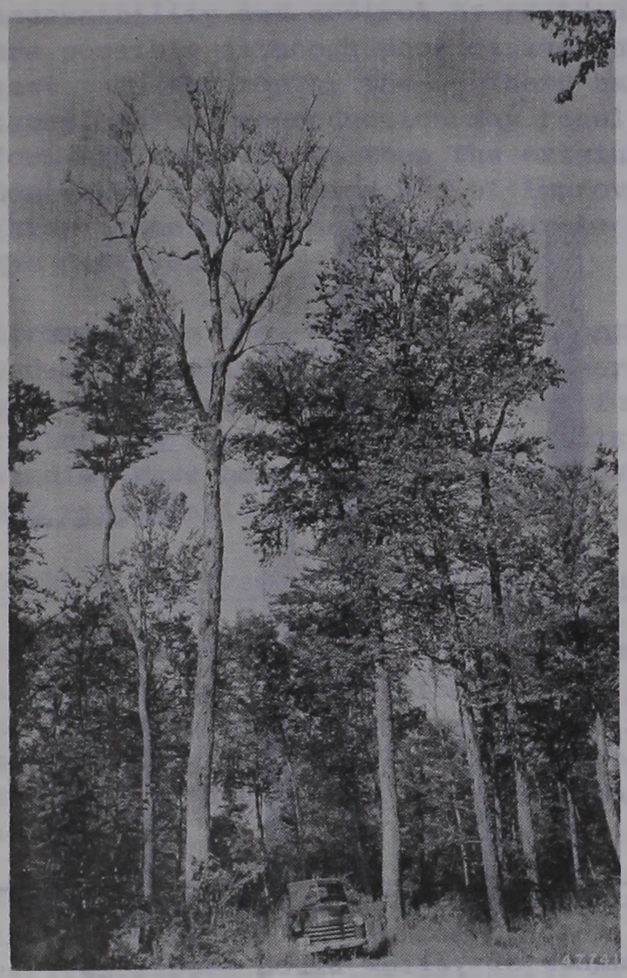
Installation of Stocking Level Study Completed

Installation of a major test of stocking levels and lengths of cutting cycle in northern hardwoods has been completed on the Upper Peninsula Experimental Forest. The study occupies about 600 acres of hardwood stands averaging 14,000 gross board feet per acre. In all instances,

each of the four intensities of cut produced enough volume per acre to give a profitable logging chance for the operator. Logging damage has been light in all cases; the proportion of valuable species in the stand has been increased. Parial cutting of old-growth northern hardwood on a continuous basis now appears to be economically practical. Long-term observation of these tests of stocking level and length of cutting cycle will yield valuable information on this point.

Injury to Crowns of Yellow Birch Observed

In late May and early June 1954, dead tops were observed in a high percentage of yellow birch trees on the Upper Peninsula Experimental Forest. Damage ranged from slight discoloration of the foliage to complete crown defoliation with a few healthy trunk sprouts. Reports were received of similar conditions in the western portion of the Upper Peninsula; no top-dying was reported in the eastern half or in Wisconsin.



Top dieback in yellow birch.

A survey made late in July showed that the larger trees in the dominant and codominant crown classes were the most seriously defoliated. Five percent of the yellow birch 15 inches in diameter and larger were seriously injured with over one-half of the crown dead. Preliminary increment core analysis indicates that the dieback had little or no effect on the year's growth, even on the most seriously defoliated trees. Permanent plot records show that similar symptoms have occurred in the past, and some trees have suffered dieback several times. Growth was not affected appreciably in any case. What has caused the tops to die remains unknown.

High Seed Production in Second-Growth Northern Hardwood Stand

Recently completed counts of the catch of seed traps under second-growth northern hardwood stands have shown a high potential for seed production. A stand with trees ranging from 7 to 15 inches in diameter produced several million seeds per acre in a good seed year. Although this value is for a stand of moderate to good stocking, even understocked stands probably produce a large quantity of seed in a good seed year. Disking of

unstocked spots in such stands before a heavy seed fall has shown promise of obtaining needed reproduction.

Disking in understocked stands to increase reproduction.

Thinning in 11-Year-Old Second-Growth Northern Hardwoods

Non-commercial thinning of very young second-growth northern hardwoods has resulted in great improvement in the quality and size of the stand. An experimental thinning schedule was set up for a series of plots in an 11-year-old second-growth hardwood stand on the Nicolet National Forest. The stand was first thinned 15 years ago; the second thinning was made 8 years later. Recent observations have shown that the thinning has improved the stand by removing individuals of poor form or species. Better spacing increased the growth, resulting in trees as large as 12 inches at 26 years of age.

Supplemental Deer Feed Produced by Non-Commercial Thinning

Non-commercial thinning of second-growth northern hardwoods has served the dual purpose of improving the stand and providing additional browse in the form of felled tops. In the winter of 1953-54, Station and Pittman-Robertson Wildlife personnel initiated a cooperative study of non-commercial thinning and cull felling in second-growth northern hardwoods both to improve the stand for timber production and to provide more feed for deer.

The current year's growth of hardwood tops and the hemlock needles from trees cut to improve the stand provided additional food for the deer herd in the area. Such thinning costs from $9 to $28 per acre, depending upon the intensity of cut, tools used, and the amount of lopping of limbs which would normally be out of range of the deer. The thinning attracted many deer, and browse utilization was good. As many as 27 deer were seen browsing on recently felled material on the 20-acre thinning area.

Plans for 1955

Top dying of yellow birch will be followed to detect any spread or intensification of symptoms. The study of physical factors affecting birch regeneration will be continued as will also studies of cull estimation and decay in northern hardwood. Methods of partial cutting

for stand improvement, and thinning in pole stands will be investigated in connection with the operation of the charcoal kiln at the Upper Peninsula Experimental Forest.

Aspen

Research in aspen management continues to be a high-priority project in the Station's program. Aspen is the most extensive type in the Lake States and is being more heavily utilized every year. During 1954, work on aspen was conducted in northern Minnesota and Wisconsin and in the Lower Peninsula of Michigan.

Some Aspen Site Factor Relationships Discovered

Both quaking aspen and bigtooth aspen occur on a wide range of soils. Growth, development, vigor, and maturity are governed to a large extent by the site on which they grow. A reliable method of early site determination is not now available to give forest managers a good estimate of the type of aspen land with which they are dealing. The study to identify site factors that control quaking aspen growth and development, undertaken in 1953 with assistance from the Minnesota Office of Iron Range Resources and Rehabilitation, was continued during 1954 in northern Minnesota.

The field work during the past year dealt with soil and timber stand conditions. Information was collected in good and poor stands to determine existing site conditions. Fifty-six soil samples obtained in the field work were analyzed in the laboratory for soil texture, soil reaction, and nutrient contents.

These analyses indicate that the soils of productive quaking aspen sites usually have a moderately high content of soil organic matter, a fairly high content of silt and clay particles, a moderate to high content of nutrient elements, and, in many cases, a high water table. Coarse-textured soils which have a deep ground-water table and are deficient in organic matter usually are poor quaking aspen sites. Generally, these soils also possess a relatively low pH value and a low content of available nutrients. Removal of the organic layer in the soil by fire considerably lowers or reduces site quality.

Costs of Improving a Bigtooth Aspen Stand with Chemical Herbicides

A cost study was made in lower Michigan of removing unmerchantable hardwoods with chemicals in an aspen stand that was partially cut 5 years ago. Hardwoods that would have no sale value at the time of the next cut were removed so that the final clear cut will be a complete one. The labor (including travel time and material) for a 3-man crew averaged 2.9 man-hours and 1.45 gallons of herbicide (3 percent 2,4,5-T and fuel oil) per acre.

Plans for 1955

Investigations of aspen site requirements will be continued in Minnesota. In Michigan work will be initiated in cooperation with the American Box Board Company on the chemical debarking of aspen and other hardwoods to study the effects upon suckering and logging costs. Work will be continued on a summary of available data on aspen management.

Pine Management

Early logging operations in the Lake States were sustained by the magnificent virgin stands of white pine; after reduction of the supply of this species, red pine gained considerable importance. Natural stands of the red and white pines and of the less desirable jack pine are still important to the economy of the region. The Station's long-time program of red pine and jack pine studies has resulted in much needed information on the management of these species. During the past year this program was strengthened by installing replications of established studies, some of them relating exclusively to white pine management. A study in a 90-year-old white pine stand, initiated to determine growth under four levels of stocking, will give important information for near-mature stands.

Red Pine Stands Show Rapid Growth Rates

On the Cutfoot Experimental Forest in northern Minnesota, the first 5-year remeasurement of a growing stock level study established in 1949 in an 85-year-old stand of red pine showed this age class to be growing rapidly in merchantable volume. On the basis of six 1/5-acre plots per growing stock level, this age class is making vigorous growth as indicated by annual increments of 500 to 800 board feet per acre for the period 1949 through 1954.

Remeasurement of a series of plots established in 1926 in a 105-year-old red pine stand near Bena, Minnesota, shows that red pine maintains a high growth rate at up to 130 years of age. Growth during the period 1949 to 1954 was 490 board feet per acre per year on stocking of 80 to 110 square feet of basal area.

Mechanical Thinning in Young Jack Pine Stands

A 7-year remeasurement of a thinning test in dense young natural jack pine on the industrial forest of the Nekoosa-Edwards Paper Company indicated, by the general trend of growth and mortality, that thinning should be undertaken while the trees still have a substantial portion of their total height in live crown. Because the material cut in such thinnings is not merchantable, reduction of the cost of the work is important. Mechanical thinning with self-propelled circular saws, followed by a mop-up operation by hand-carried 10-inch circular power saws, has greatly reduced the cost of thinning as compared to expensive hand

thinning with ax or brush knife. Costs of thinning with power equipment have been reduced to $8 per acre with prospects of still further reduction through improved techniques.

Plans for 1955

Data on the 25-year results of jack pine thinnings will be gathered. A series of plots established 20 years ago dealing with jack pine reproduction will be checked. The 1,000-acre red pine management unit on the Cutfoot Experimental Forest will be reinventoried to determine growth of the past 15 years.

Swamp Conifer Types

In Minnesota, Wisconsin, and Michigan, there are 6,300,000 acres of commercial swamp conifer forests. Black spruce and balsam fir pulp from these forests are used extensively by Lake States pulp mills, and white-cedar and tamarack are marketed as posts, poles,mine material, and other products. The supply of domestic spruce has not been sufficient to meet the demands of the paper industry for several years, and much pulpwood is imported from Canada to fill the gap between supply and demand. White-cedar and mixed conifer swamps are also important as wintering areas for deer.

The project aimed at determining the logging practices that can best be used to perpetuate the more valuable conifer components of the mixed swamp type has continued to go forward in 1954. Cuttings have now been established in northern Michigan on lands of the Escanaba Paper Company, the Bonifas Lumber Company, the Patton Lumber Company, and on the Upper Peninsula Experimental Forest.

A management unit designed to study costs and returns of a managed black spruce swamp forest is now in operation on the Big Falls Experimental Forest in cooperation with the Minnesota Division of Forestry. The best silvicultural and management practices known are being used.

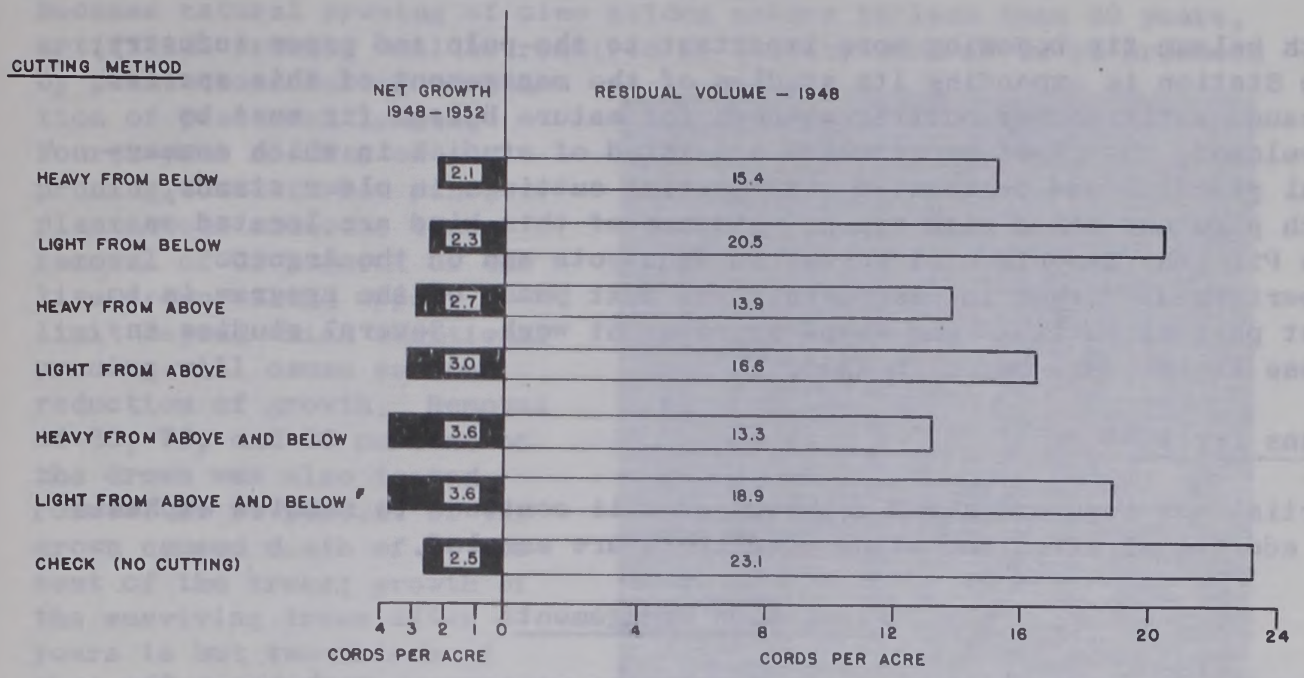
Reproduction Cutting in Mature Swamp Spruce

Further progress has been made on a large-scale study of the problems of obtaining natural reproduction of black spruce. This project is a cooperative venture with the Minnesota Conservation Department on the state-owned Big Falls Experimental Forest. Six cutting methods have been sampled so far--clear cutting in strips, clear cutting in small patches, group selection cutting, light tree selection cutting, heavy shelterwood cutting, and light partial cutting aimed at even-age management. Data were also collected on uncut check areas.

General field observations indicate that density of the overstory, logging slash, and ground scarification by skidding are some of the factors most strongly influencing reproduction success.

Growth of 75-Year-Old Black Spruce After First Pulpwood Thinning

In 1948 a tract of 75-year-old black spruce on the Chippewa National Forest was thinned for pulpwood by six different cutting methods. Growth results 5 years after logging were analyzed during the past year. Light cutting from both the upper and lower crown canopy with a residual stand of about 90 square feet of basal area resulted in the most growth. This method produced a net increase of 3.6 cords per acre in 5 years.



Five-year growth per acre of 75-year-old swamp black spruce in relation to cutting methods.

These plots also clearly demonstrated that submerchantable trees in the intermediate and suppressed classes can still respond to release through cutting in a relatively young black spruce stand such as this. Ingrowth of such trees into pulpwood size contributed as much as 22 percent of the net growth during the first 5 years.

Eliminating Brush Competition in Deforested Conifer Swamps

Two deforested conifer swamps in Minnesota, one near Hill City and the other near Big Falls, were sprayed from the air with herbicides by the Minnesota Division of Forestry in the summer of 1954. A good kill of alder, willow, and other brush species was obtained with mixtures of 2,4,5-T and 2,4-D esters in diesel oil and water. The Station is cooperating in these projects which are attempting to find economic methods of restoring black spruce to such badly deforested sites. Seedling and transplant black spruce stock was planted in both areas last fall. Survival counts and other data will be collected by the Station.

Plans for 1955

Fundamental soil-site studies in black spruce swamps will be initiated. Two more replications of the cutting-methods study in mixed swamp conifers will be installed, one on the Upper Michigan National Forest and one by the State of Michigan in the Upper Peninsula. The Station will also assist the State of Minnesota with spring planting of aerial-sprayed spruce swamps and make survival studies in these plantations.

Balsam Fir

With balsam fir becoming more important to the pulp and paper industry, the Station is expanding its studies of the management of this species. Because satisfactory cutting methods for mature balsam fir must be developed, the first experiments consisted of studies in which commercial practice was contrasted with partial cuttings in older stands, both pure and mixed with aspen. Studies of this kind are located on the Pike Bay Experimental Forest in Minnesota and on the Argonne Experimental Forest in Wisconsin. The next phase of the program is to test partial cuttings and stand-improvement work. Several studies in these fields were begun in 1954.

Plans for 1955

Partial cuttings and stand improvement will continue to receive emphasis as additional sites and stand conditions are sampled.

Plantation Management

Progress was made during 1954 in developing management techniques for the more than one million acres of successful pine plantations in the Lake States region. Since planted pine are evenly spaced, their management up to the time of the second or third commercial thinning is somewhat different from that of natural stands in regard to the need for pruning and thinning. Unique protection problems may also arise because the uniformity of plantations may make them especially susceptible to certain kinds of damage.

Some of the major projects completed include: (1) a plantation release handbook for northern Minnesota in cooperation with the Iron Range Resources and Rehabilitation Commission, and (2) a bulletin on pruning pine in Michigan in cooperation with Michigan State College. Both of these reports will be published early in 1955.

Soil Moisture and Snow Accumulation in a Red Pine Plantation

Assistance has been given Michigan State College in conducting a series of observations of soil moisture and snow accumulation in a thinned plantation at Higgins Lake in lower Michigan. Soil moisture dropped as low as 3 percent in the sandy soil during August regardless of residual stand density.

Snow accumulation at the same site followed the general pattern observed in other regions. Throughout the winter, depth in the open was twice that in the densest part of the plantation. Where thinning had been done, the snow depth was related closely to the stand density, more snow being found where the stand density was least. In the spring the snow was retained, on the average, about two weeks longer in the plantation than in the open.

Pruning Tests

Because natural pruning of pine seldom occurs in less than 80 years, artificial pruning will be required if quality wood is to be produced by plantations during a rotation of practical length. Fourth-year results of pruning tests in red pine plantations indicate that removal of 50 percent of the live crown is the upper limit beyond which additional pruning will cause serious reduction of growth. Removal of 30, 70, and 90 percent of the crown was also tested. removal of 90 percent of the crown caused death of 30 percent of the trees; growth of the surviving trees after 4 years is but two-thirds of that of unpruned check trees.

Early thinning and pruning of this red pine plantation would have improved growth and wood quality.

Plans for 1955

Plans are being made to: (1) establish additional white pine release plots in lower Michigan to determine the minimum amount of shading required for resistance to weevil damage, (2) establish a growing stock level study in planted jack pine in lower Michigan, (3) make an appraisal of potential red pine pole supply in lower Michigan in cooperation with Consumers Power Company and other utility companies, (4) explore the feasibility of using pneumatic type orchard pruning equipment for pruning pine, and (5) prepare a 5-year summary of annual pruning.

Nursery Research

The Lake States area has in the past been outstanding in the size and quality of its planting program. Research has played an important role in the development of reliable and efficient nursery operation to produce healthy planting stock at reasonable cost. During the past year the first draft of a comprehensive technical bulletin on nursery practice in this region was prepared for publication jointly with National Forest Administration.

Chemical Herbicides in Forest Management

The use of chemical herbicides is becoming one of the more important forest management practices in the Lake States region. In fact, the large-scale use of cutting tools without the help of chemicals for controlling unwanted brush and trees is now about obsolete. However, much remains to be learned in the techniques of applying chemical herbicides to increase their effectiveness and to further reduce costs of application. This is true particularly of aerial sprays.

Significant progress was made during 1954 in the use of aerial sprays for controlling broadleaf brush and inferior-quality hardwoods for forest and game management purposes. During the past year approximately 5,400 acres were aerial-sprayed in the Lake States region, primarily for the release of coniferous plantations. Costs were generally less than $5 per acre. An example of the results desired is shown on an area sprayed 4 years ago where aspen suckers, hazel brush, and willows were overtopping natural and planted pine seedlings. In the sprayed area an average of only 18 percent of the conifers need release as compared to 83 percent where no spraying was done.

Spraying also has possibilities in killing brush and thus encouraging the invasion of pine seedlings. Plots sprayed with 2,4-D now have 60 to 160 percent more seedlings than they did 7 years ago before treatment, compared to a gain of only 2 percent on unsprayed plots. Moreover, these seedlings are not only larger than those on the check plots, but fewer of them need release. That this benefit is a direct result of the spraying is shown by the fact that the brush on the sprayed plots is now much lighter in density and also shorter than that on the unsprayed plots although the two areas were originally similar in this respect.

Tolerance of Conifers to 2,4-D and 2,4,5-T High After August 1

A study of the effects of simulated aerial spray applications on six conifer species at different stages of growth was completed in lower Michigan this summer. Various mixtures of 2,4-D and 2,4,5-T esters in oil and water were used to spray the foliage of 15-year-old planted red pine, white pine, jack pine, Scotch pine, Norway spruce, and white spruce during the growing season.

The 2,4-D and 2,4,5-T esters were applied to each of these 6 species at rates of 1 and 2 pounds of acid equivalent in both 2 1/2 and 5 gallons of carrier per acre every 10 days from June 8 to August 18. The carrier consisted of 1 quart of diesel oil and sufficient water to make up a volume of either 2 1/2 or 5 gallons of mixture per acre.

The new growth and some old growth of all species were killed or damaged during the period of active growth (June and July) by all of the chemical mixtures tried regardless of their concentration or volume per acre. During the early growth period (June) the 2,4-D mixtures damaged the conifers more than the 2,4,5-T.

The chemical herbicides tested had no apparent effects on white spruce after July 15, and after August 1 for the remaining species except jack pine, which exhibited some browning of the foliage up to August 15.

From this experiment it appears that aerial sprays consisting of 2 pounds acid equivalent of either 2,4-D or 2,4,5-T esters in oil-water carriers up to 5 gallons per acre can be used after August 1 in lower Michigan for controlling broadleaf plants without serious damage to the conifers. The results of this experiment which simulated aerial spraying by ground application are conservative because of the greater loss of spray material which is encountered in aerial operations.

Summer and Fall Months Best Time for Chemical Frill Girdling

In the Lake States the most common method of controlling individual weed trees with chemicals for forest management purposes is the frill-girdle method which consists of adding a 1-percent mixture of 2,4,5-T in fuel oil to a single shallow cut made completely around the base of the tree at a convenient chopping height. Although the tops of nearly all species of trees in this region may be killed effectively in this manner at any season of the year, the number of sprouts that develop vary with the season of treatment.

Results from tests installed 3 years ago in lower Michigan reveal that only one-third of the hardwoods sprouted when treated with chemical frill girdles during the summer and fall (July through October), whereas about one-half of the trees similarly treated during the winter and spring (December through May) sprouted. Placing the frill girdle close to the root collar during the summer and fall months resulted in little or no sprouting for red maple, a species ordinarily most prolific in sprouts. Consequently, where sprout growth needs to be reduced to a minimum as in releasing small pine from a hardwood overstory, chemical frill girdling should be done during the summer and fall. Hardwood species that are prolific sprouters, such as red maple, wild cherry, etc., should be frill-treated close to the root collar.

Plans for 1955

The effective use of chemical herbicides as tools in forest management will be studied further in northern Minnesota and lower Michigan. This

will include tests of minimum dosages required to control hazel, alder, aspen, and other herbicide-resistant species.

Farm Forestry Studies

The Station's work in farm forestry is aimed at improved practices in the management of small woodlots and better use of wood products about the farm. This work is closely dovetailed with other agencies--state, federal, and private--which are actively engaged in promoting better forestry on the farm woodlot. For several years the University of Minnesota and this Station have cooperated in making fencing studies and in investigations of preservative treatment of wood products such as posts, poles, and rough lumber for farm use.

Combined demonstration and research areas termed "Timber Harvest Forests" or "Farm Forestry Forties," of which there are 15 in the Lake States, received scheduled cuttings and were visited by many landowners interested in exploring the practicality of better management methods.

Cooperation With the University of Minnesota

Studies of farm fencing continue to yield results of practical interest. Tests with power-driven posts show that satisfactory fences can be constructed even when the soil is extremely dry. This has special value because the difficulty of setting fence posts firmly by hand in extremely dry soils is well known; the powdery soils make firm tamping of the fill around the post impossible. In another test, posts were driven with sufficient accuracy to permit board fence construction.

A power driver for wood posts.

Several miles of experimental fences were built to study variation in post spacing and fence height. One fence was built with smooth wire strung through holes drilled through the fence posts; no staples were used. Service tests of fencing variations are under way at several of the field stations of the University of Minnesota.

A 98 x 30-foot fully insulated and treated pole hog house with double walls is being built by the Division of Animal Husbandry

at the Rosemount Research Center, Institute of Agriculture, University of Minnesota. The Station has cooperated in the design of the structure, processing and treating of the material, and to a limited extent, in construction to effect a satisfactory pattern for use of treated lumber.

Timber Harvest Forest Production

Second-growth hardwood stands can produce considerable stumpage and revenue for the landowner, even when the poor condition of the stands permits no more than improvement cutting. A demonstration "forty" on the Argonne Experimental Forest produced in an 8-year period 43,000 board feet of sawlogs, 34 cords of softwood pulpwood, and 126 cords of fuelwood, all with a total stumpage value of $737. The per-acre per-year stumpage return was $2.40. Additional value would accrue to the landowner who could harvest the timber himself and thus sell his labor in addition to the stumpage.

One year's harvest on a demonstration forty; it represents 1 year's growth.

Regeneration of Oak Woodlots

Scarification, following a bumper acorn crop, has increased the amount of seedling regeneration of northern red oak from approximately 1,000 to 3,000 trees per acre after three growing seasons. The mineral seedbed was exposed by means of an Athens disk or by hand work with a mattock. Cheaper and more effective methods of doing the work are needed.

A study just completed indicates that northern red oak seedlings can survive under quite unfavorable conditions of competition. However, survival was poor on the sites which have both a closed overstory and a very dense ground cover of herbaceous and woody plants. In all cases the growth of the regeneration was not satisfactory, as shown by the fact that these small trees averaged only 6 to 8 inches in height after 5 growing seasons. The air-dry weight of the northern red oak seedlings grown under a very dense ground cover averaged 2.0 grams as compared to 4.8 grams and 6.0 grams, respectively, per tree under conditions of moderate and light shade. The results of this study will be published soon.

Plans for 1955

Tamarack will make a satisfactory fence post if some of the problems connected with peeling and preservative treatment can be solved. Work already started on this species will be continued. In the major study of fence construction to be undertaken, several methods of pointing posts to be set with a power driver will be compared based on the ease with which they can be driven and the firmness with which they are set.

Farm woodland management studies will be continued essentially on the present basis, with cost and returns information and experience in silviculture to be summarized periodically for general distribution.

Mensuration

Composite Volume Tables Soon to be Available

A technical bulletin on composite volume tables and their application, summing up the Station's work in the field of volume tables, will soon appear in print. Additional work on this project will involve: (1) development of a systematic test procedure for those desirous of checking the applicability of composite tables to new species or to other regions, and (2) evaluation of volume above the last usable log in hardwood trees. The work on estimation of the volume of topwood is now under way, based on data obtained in 1953.

More Efficient Techniques for Estimating Growth Being Sought

Permanent plots established by different forest agencies in the region now offer an excellent opportunity for checking the accuracy of different growth prediction methods and for developing more efficient techniques. The aim is to develop a standard or uniform approach requiring a minimum number of field measurements and very little office work. A further aim is to evolve a general approach applicable to both pure and mixed stands, and to even-aged as well as uneven-aged conditions of growth.

A cooperative study of growth and mortality in the spruce-balsam type, now being considered with the Lake States Council of Industrial Foresters, will provide a good start on this long-term project.

A Test of Bitterlich's Point Sampling Method

The Station and National Forest Administration are jointly testing the applicability of Bitterlich's point sampling method to forest management plan inventories. The test is being made in different types of the Upper Michigan National Forest.

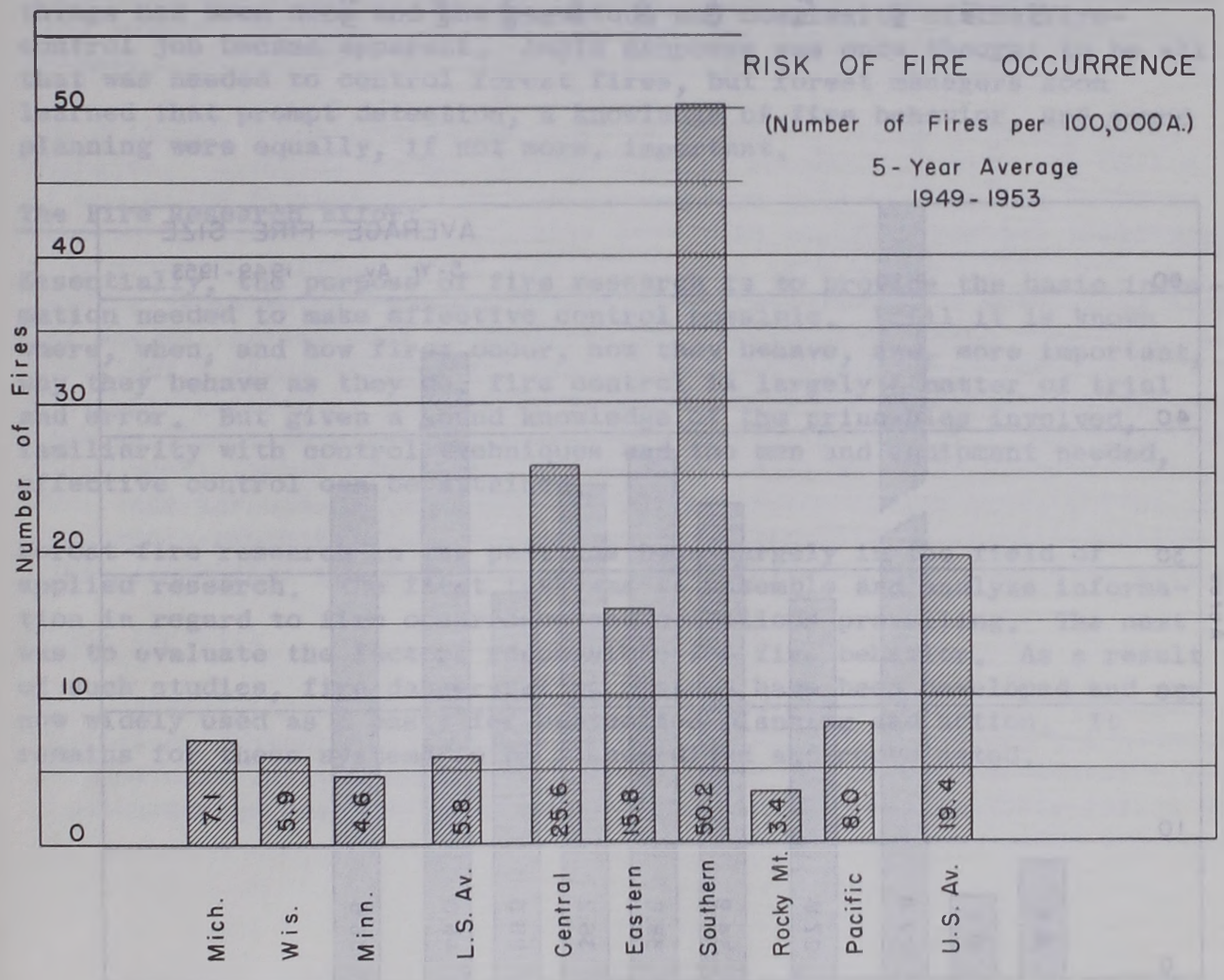
FOREST PROTECTION

Research on the protection of our forests from the inroads of fire, insects, and disease is essential. New diseases crop up; insects migrate or are brought in from other regions and even other countries; and fire is an ever-present threat. Of importance, too, is the protection of our wildlife, particularly the birds and larger mammals, from starvation or extinction through poor range conditions, over-population, or improper hunting regulations. Research studies are also carried on in regard to the destruction of young seedlings by wildlife species.

Forest Fire Research

30 Years of Progress in Fire Protection

Progress in fire control in the Lake States in the past 30 years is impressive. The average number of fires per year has been reduced over 60 percent and the mean annual burn 90 percent. This improved protection permitted over 22 million acres of young growth to become established on previously cut and burned-over land. Furthermore, over 15 million acres of pole and larger timber have been protected and allowed



PERCENT BURNED
5 - Year Average
1949 - 1953
Percent
0.0
0.5
1.0
1.5
0.06
0.04
0.36
0.16
0.89
0.61
1.81
0.10
0.37
0.67
Mich.
Wis.
Minn.
L.S. Av.
Central
Eastern
Southern
Rocky Mt.
Pacific
U.S. Av.

AVERAGE FIRE SIZE
5-Yr. Av. 1949-1953
Acres
0
10
20
30
40
50
8.5
6.1
77.6
27.9
34.9
38.8
36.2
28.5
46.0
36.6
Mich.
Wis.
Minn.
L.S. Av.
Central
Eastern
Southern
Rocky Mt.
Pacific
U.S. Av.

to develop. A mean annual burn of only 0.16 of 1 percent of the area protected indicates the current over-all effectiveness of protection effort. While this is adequate for timber production, it does not mean that the forest-fire problem has been solved or that there can be any letdown in protection effort. In the Lake States, for example, there are, on the average, 124 potential fire days a year of which 43 are acute and 5 extreme. Some years are much worse. The chief difficulty is that the fire season is erratic and largely unpredictable.

How the three Lake States compare with each other and with other regions in number of fires per unit area, percentage of protected area burned, average fire size and percentage of large fires is shown graphically in the accompanying figures.

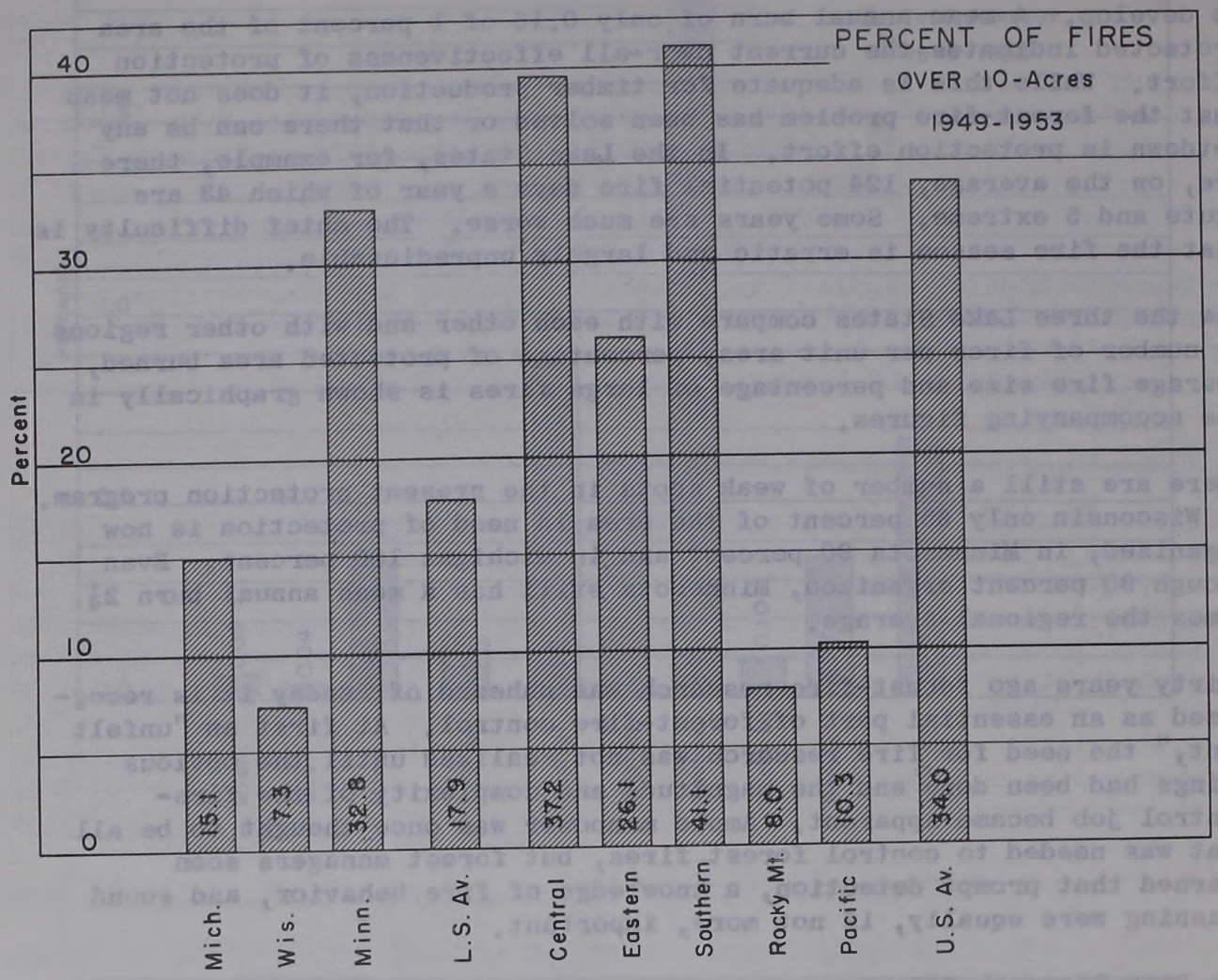
There are still a number of weak spots in the present protection program. In Wisconsin only 65 percent of the area in need of protection is now organized, in Minnesota 90 percent and in Michigan 100 percent. Even though 90 percent organized, Minnesota still has a mean annual burn $2\frac{1}{4}$ times the regional average.

Thirty years ago forest-fire research was unheard of; today it is recognized as an essential part of forest-fire control. At first an "unfelt want," the need for fire research was not realized until the obvious things had been done and the magnitude and complexity of the fire-control job became apparent. Ample manpower was once thought to be all that was needed to control forest fires, but forest managers soon learned that prompt detection, a knowledge of fire behavior, and sound planning were equally, if not more, important.

The Fire Research Effort

Essentially, the purpose of fire research is to provide the basic information needed to make effective control possible. Until it is known where, when, and how fires occur, how they behave, and, more important, why they behave as they do, fire control is largely a matter of trial and error. But given a sound knowledge of the principles involved, familiarity with control techniques and the men and equipment needed, effective control can be attained.

Forest-fire research in the past has been largely in the field of applied research. The first task was to assemble and analyze information in regard to fire occurrence and conditions prevailing. The next was to evaluate the factors responsible for fire behavior. As a result of such studies, fire danger-rating systems have been developed and are now widely used as a basis for protection planning and action. It remains for these systems to be standardized and coordinated.



Suggestions for the Future

While protection from forest fires in the Lake States at present is adequate under normal conditions, the problems of fire prevention and of fire control under acute conditions call for further study. The prediction of burning conditions deserves particular attention. In addition, specific information is needed as to the silvicultural, biological, hydrological, economic, and social effects of forest fires as a basis for sound damage estimates and for the determination of the justifiable limits of protection expenditures. The possible usefulness of fire as a tool in forest-land management also remains to be explored.

Forest Insects

A temporary reduction in the staff of the Division of Forest Insect Research and Surveys necessitated some curtailment of research during 1954. Toward the end of the year, however, additional funds allotted for insect studies made possible an enlarged staff and an expansion in plans for 1955.

The efforts of this division involve both research and detection surveys. Research in 1954 was directed toward biological and ecological studies of defoliators and sucking insects and toward improvement of survey methods. Surveys were made to determine the abundance and distribution of the more serious insect pests. In both research and survey projects, close cooperation is maintained with all interested private, state, and federal agencies.

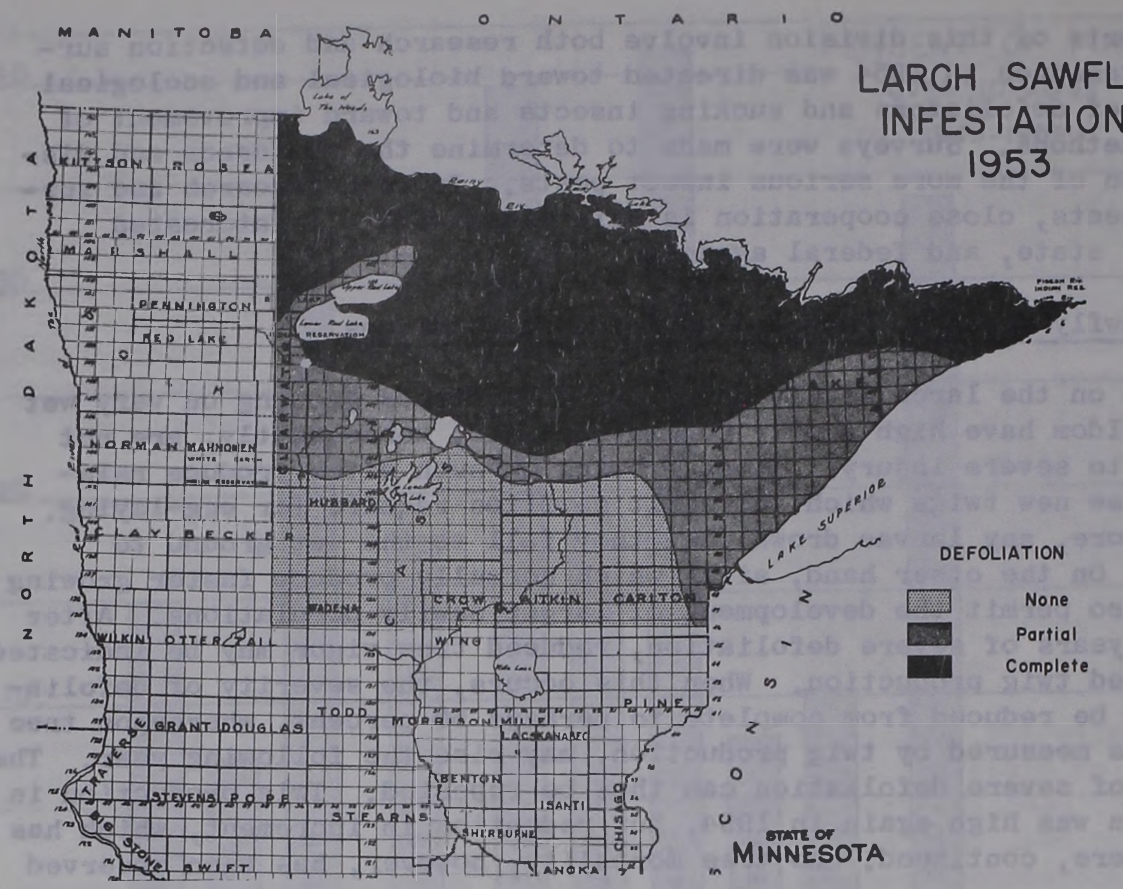
Larch Sawfly Research Expanded as Epidemic Continues

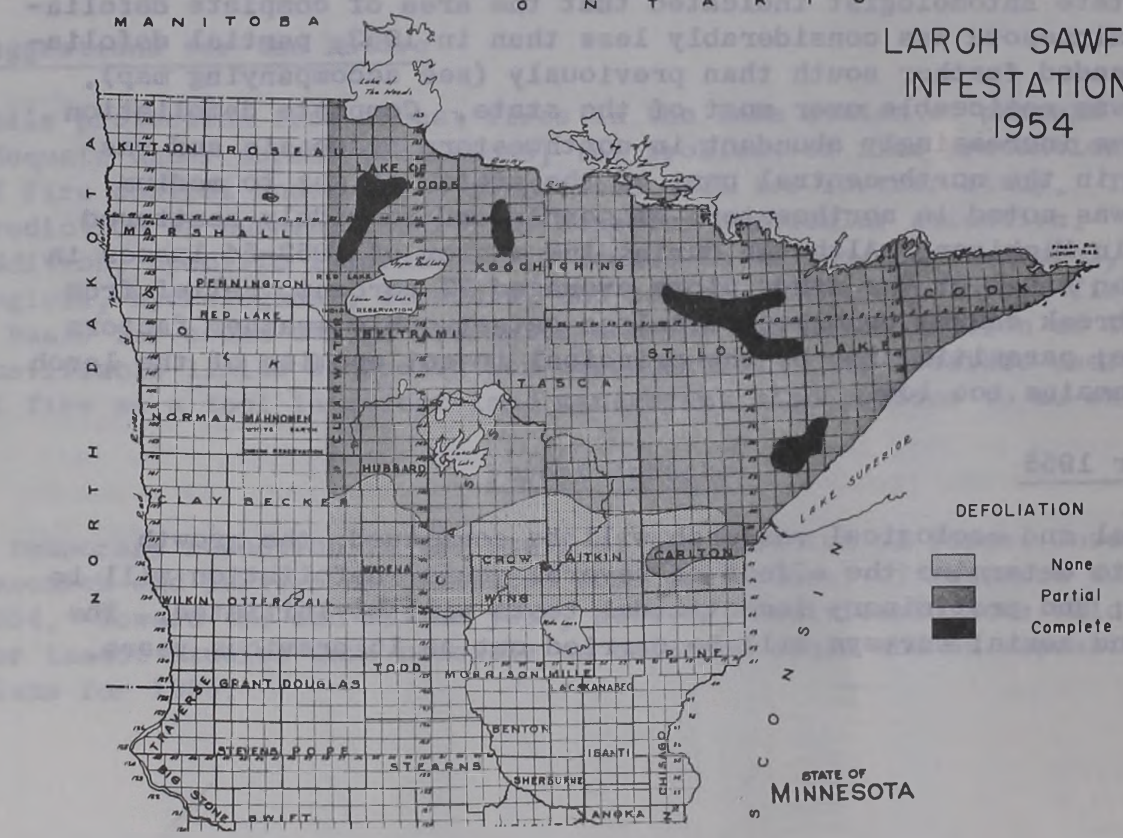
Research on the larch sawfly has shown that stands growing on very wet sites seldom have high sawfly populations and, consequently, are not subject to severe injury. Trees growing on such sites produce relatively few new twigs which the adult sawflies require for egg-laying. Furthermore, any larvae drown when they fall to the wet ground to cocoon. On the other hand, sites which normally produce faster growing trees also permit the development of larger sawfly populations. After several years of severe defoliation, reduced tree vigor may be indicated by lowered twig production. When this occurs, the severity of defoliation may be reduced from complete to perhaps 50 percent, whereupon tree vigor, as measured by twig production, may rise the following year. The pattern of severe defoliation can thus be repeated. Twig production in Minnesota was high again in 1954, but reduction in increment, which has been severe, continued. No tree mortality, however, has been observed to date.

The outbreak conditions which arose in Minnesota about 1949 continued unabated. Although aerial surveys made in cooperation with the Office of the State Entomologist indicated that the area of complete defoliation in Minnesota was considerably less than in 1953, partial defoliation extended farther south than previously (see accompanying map). Feeding was noticeable over most of the state. Complete defoliation has become increasingly abundant in northwestern Wisconsin and was reported in the north-central part of the state. Light to medium feeding was noted in northeastern Wisconsin and in widely scattered pockets in Michigan. Although during the winter of 1953-54 losses in the cocoon stage at the study plots averaged 77 percent, relief from this outbreak cannot be expected unless catastrophic weather factors intervene; parasitization by the principal insect enemies of the larch sawfly remains too low.

Plans for 1955

Biological and ecological research will be continued; the growth studies to determine the effect of several years' defoliation will be expanded; and preliminary insecticidal tests will be initiated. The ground and aerial surveys will be carried out as in previous years.


LARCH SAWFLY
INFESTATION
1953
MANITOBA
ONTARIO
NORTH DAKOTA
KITTSON
ROSEAU
MARSHALL
PENNINGTON
RED LAKE
NORMAN
MAHNOMEN
HUBBARD
CLAY
BECKER
WADENA
CROW WING
AITKIN
CARLTON
LAKE SUPERIOR
WILKIN
OTTER TAIL
TODD
MORRISON
MILLE LACS
KANABEC
PINE
GRANT
DOUGLAS
TRAVERSE
BIG STONE
STEVENS
POPE
STEARNS
BENTON
ISANTI
CHISAGO
SHERBURNE
SWIFT
ANOKA
WISCONSIN
STATE OF
MINNESOTA
DEFOLIATION
None
Partial
Complete


LARCH SAWFLY
INFESTATION
1954
MANITOBA
ONTARIO
NORTH DAKOTA
KITTSON
ROSEAU
LAKE OF THE WOODS
MARSHALL
PENNINGTON
RED LAKE
KOOCHICHING
BELTRAMI
COOK
LAKE
TASCA
NORMAN
MAHNOMEN
HUBBARD
CLAY
BECKER
WADENA
CROW WING
AITKIN
CARLTON
LAKE SUPERIOR
WILKIN
OTTER TAIL
TODD
MORRISON
MILLE LACS
KANABEC
PINE
GRANT
DOUGLAS
TRAVERSE
BIG STONE
STEVENS
POPE
STEARNS
BENTON
ISANTI
CHISAGO
SHERBURNE
SWIFT
ANOKA
WISCONSIN
STATE OF
MINNESOTA
DEFOLIATION
None
Partial
Complete

Pine Sawflies Are Increasing in Importance

An increasing number of reports during the past 3 years indicate a general rise in populations of the several species of pine sawflies. Due to the confused taxonomic status, positive species determination has not always been possible. The International Committee, formed in 1953 to develop a program on the taxonomy and biological and ecological factors, has made considerable progress. Both in this region and elsewhere, individual larval colonies have been reared and the adult and larval forms preserved. Whenever possible, ecological information pertaining to each group is recorded and forwarded to the principal taxonomists on the Committee. It is believed that this information will be of great value in determining the various species of pine sawflies in this area.

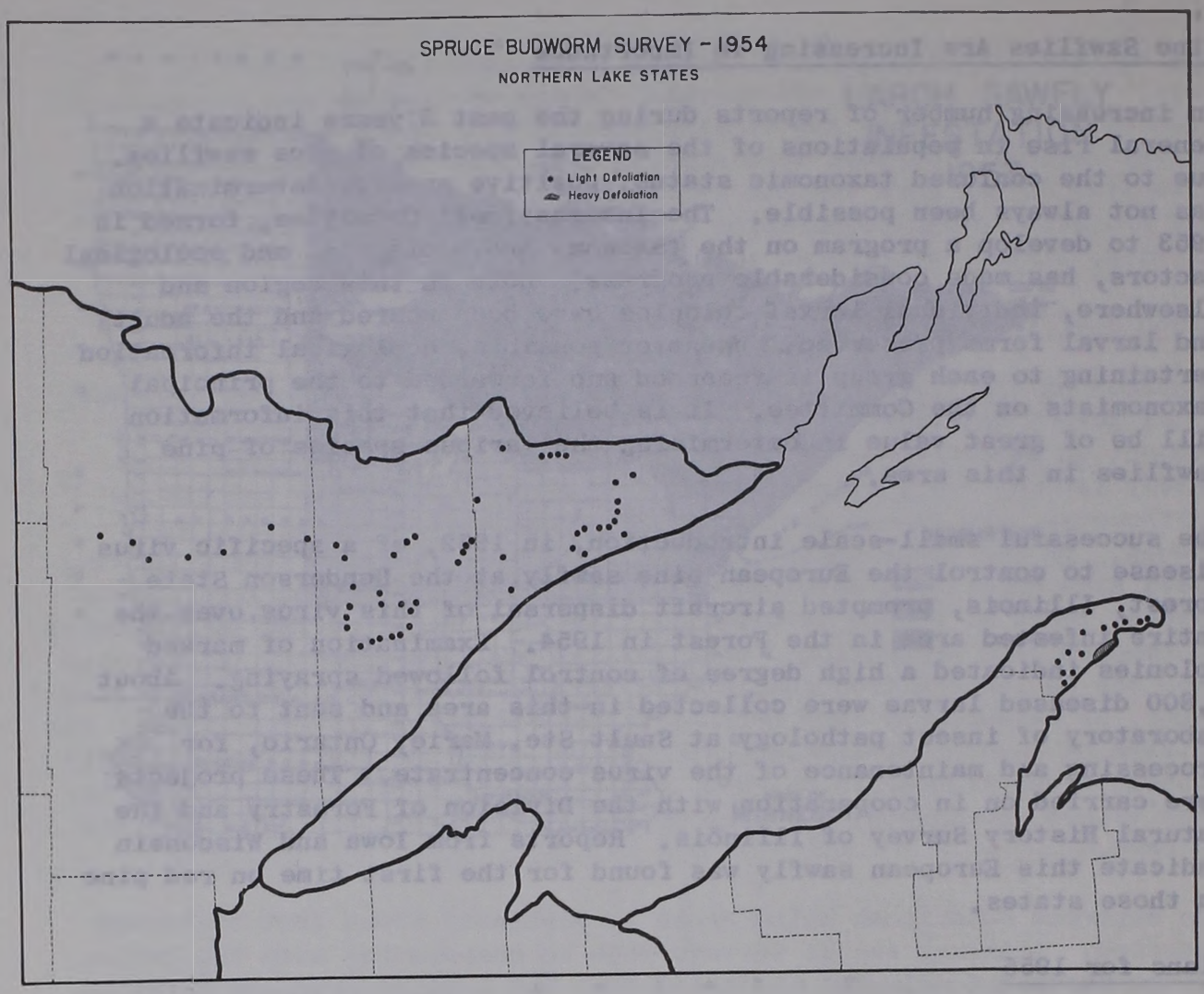
The successful small-scale introduction, in 1952, of a specific virus disease to control the European pine sawfly at the Henderson State Forest, Illinois, prompted aircraft dispersal of this virus over the entire infested area in the Forest in 1954. Examination of marked colonies indicated a high degree of control followed spraying. About 4,800 diseased larvae were collected in this area and sent to the laboratory of insect pathology at Sault Ste. Marie, Ontario, for processing and maintenance of the virus concentrate. These projects were carried on in cooperation with the Division of Forestry and the Natural History Survey of Illinois. Reports from Iowa and Wisconsin indicate this European sawfly was found for the first time on red pine in those states.

Plans for 1955

Field work will be confined largely to the rearing of individual colonies of larvae for taxonomic studies by the International Committee. The virus spray project to control the European pine sawfly in Illinois will be checked to determine the degree of dispersal of the virus; also a small cooperative spray program in the southeastern part of Iowa is under consideration. The laboratory of insect pathology at Sault Ste. Marie will field-test a virus disease against the red-headed pine sawfly. If the tests are successful, it is likely this material will be made available for use a year later.

The Spruce Budworm Returns

The spruce budworm, which has caused more monetary loss in the coniferous forests of the United States and Canada than any other single insect, is now a definite threat to the spruce-fir types in the Lake States. Industry, state, and federal agencies are cooperating with the Station on this problem. The younger age classes of balsam fir which survived the 1910-26 epidemic in Minnesota have now reached a susceptible age and size. Surveys in 1954 disclosed light populations of the insect in most of the stands on the Superior National Forest and adjacent areas in Cook, Lake, and St. Louis Counties (see accompanying map). Caterpillars were also found on the Chippewa National Forest in northern



Itasca County. Over an area of about 2,500 acres in the Keweenaw Peninsula, Michigan, a heavy infestation of several years' standing has caused almost complete defoliation of dominant balsam fir and heavy defoliation of intermediate black spruce. Elsewhere in this peninsula observations showed feeding occurred in 1954. The insect was also found in Wisconsin about 160 miles south of the Keweenaw infestation. Although surveys were not made in the intervening country, it is highly probable the insect was present.

Plans for 1955

Present plans for research include studies on (1) life history and habits for comparison with eastern and western findings, (2) natural control factors, (3) methods for measuring populations, (4) climatic factors, (5) relation between populations and degree of defoliation in different stand densities and types, (6) susceptibility of different host species to feeding, (7) growth and cutting practices, and (8) adaptation and improvement of existing survey methods to forest types and terrain in the Lake States, and determining whether current feeding is noticeable from the air.

Plans for surveys are (1) development of a uniform system for detecting and reporting the presence of the spruce budworm, which can be used by all interested land-managing or land-owning agencies, and (2) aerial and ground reconnaissance and mapping of the extent and severity of the infestation.

The Jack-Pine Budworm Threatens Lake States Jack Pine Stands

Research on the jack-pine budworm was confined to collections of full-grown caterpillars and pupae in upper Michigan stands for use in parasite studies to be made this winter.

Surveys by State agencies in 1954 indicated that the jack-pine budworm is increasing in abundance in the jack pine stands throughout the northern Lake States. Populations in Michigan, in general, were low. Although the infestation in the Superior State Forest in the Upper Peninsula has not increased in area, feeding was more intense in the eastern part of this forest than in 1953. In northwestern Wisconsin, the area of reported heavy feeding increased from 1,000 acres in 1953 to more than 20,000 acres in 1954. Heavy defoliation of 2,000 acres of mature jack pine in Marinette County was also reported. In Minnesota, mature stands covering at least 8,000 acres in Beltrami, Hubbard, and Wadena Counties suffered heavy defoliation.

Plans for 1955

Collection activities to determine the role of natural control factors in the development and decline of infestations, previously confined to upper Michigan, will be expanded in 1955 to include larval and pupal material from Wisconsin and Minnesota. It is understood that studies of the insect itself will be made by state agencies in Minnesota and Wisconsin.

Saratoga Spittlebug Still a Plantation Problem

Additional research on surveys in 1954 showed promise that the extensive fall feeding puncture surveys on the Saratoga spittlebug can be discontinued; surveys in the late stages of nymphal development will, it is believed, give information for predicting the next year's populations as well as for providing acreage estimates for immediate control operations. Sweep surveys and spot feeding puncture checks in areas which were not sprayed or in those just reaching susceptible height will be necessary, but will not require additional manpower.

There is evidence of a relationship between nymphal and adult populations and changes in tree form. The field data for these 1954 studies have not been completely analyzed, and at least one more season's research will be necessary before final conclusions can be reached. Further study of growth retardation due to adult feeding indicated the impracticability of the general use of this principle as a survey tool: analysis is time-consuming and impractical for the non-technical

personnel who carry out field work. However, if a "rule-of-thumb" can be developed it will be of great value in making a quick determination of the damage threshold.

Based on nymphal surveys, 7,206 acres of red pine plantations on national forests in Wisconsin and upper Michigan were sprayed with DDT by airplane to prevent further damage in these plantations by the spittlebug. This was a very substantial reduction from the 11,280 acres treated in 1953. Fall feeding puncture surveys in 1954 indicated that 7,512 acres in the open where spraying would be effective had a sufficiently high adult population to warrant control recommendations. Release of additional heavily infested plantations under hardwood overstory would increase this acreage, but the actual acreage needing treatment cannot be definitely determined until the nymphal surveys are made in June.

Plans for 1955

Research on population sampling and feeding intensity, and on their relation to tree condition (height, crown diameter, and vigor) and stand density will be continued. Studies of nymphal populations and alternate host preferences and of improvement in survey techniques will also be carried on.

The European Pine Shoot Moth a Menace in Lower Michigan

A third mild winter in lower Michigan and eastern Wisconsin permitted the continuance of serious infestations of the European pine shoot moth in many red pine plantations and on ornamental pines throughout the south half of lower Michigan and along the Lake Shores as far north as Harrisville and Traverse City in Michigan and Manitowoc in Wisconsin. Plantations in the vicinity of Muskegon have suffered severely, many trees being stunted and of poor form. Insecticidal treatments, generally speaking, have proved unsatisfactory, and advice on large-scale spraying must await the results of experiments by the Northeastern Forest Experiment Station.

Plans for 1955

Survival and cold hardiness studies are being continued in Michigan. In order to have a record of the lowest temperature in an infested area, minimum temperature thermometers have been placed at three heights in three locations in a heavily infested plantation near Harrietta, Michigan, about 20 miles west of Cadillac. These temperatures will be compared with the records of the Weather Bureau station at Cadillac, as a check against previous studies. A correlation between "winter" mortality and temperatures will be established next spring.

Miscellaneous Surveys

Walkingstick egg surveys indicated that heavy defoliation will occur on about 1,200 acres of oak woodland on the Menominee Indian Reservation, Wisconsin, in 1955. A DDT airplane spray operation has been recommended.

Pine tortoise scale surveys in Wisconsin showed that a marked decline in scale populations had occurred in the 1954 generation. This was caused by the predatory activity of the larval and adult stages of ladybird beetles. Heavy-scale attacks were reported in Schoolcraft and Delta Counties in upper Michigan, but natural control was less noticeable in these areas. Two spray projects on the Nicolet National Forest--a high-pressure ground operation using liquid lime sulphur at 1 part to 25 parts of water, and an airplane operation using approximately 2 pounds of emulsifiable DDT in 4 gallons of water per acre--appeared to give good results, but the actual degree of control could not be determined because of the predation factor. Similar results were experienced in control operations carried on by state and county agencies and by the University of Wisconsin in Marinette County, Wisconsin.

Forest tent caterpillar egg mass surveys indicated that the epidemic conditions in Minnesota and Michigan are virtually at an end. One more year of heavy feeding is expected in northwestern Wisconsin, but high parasite populations, chiefly of the fly, Sarcophaga aldrichi Park., should materially reduce the 1955 moth population.

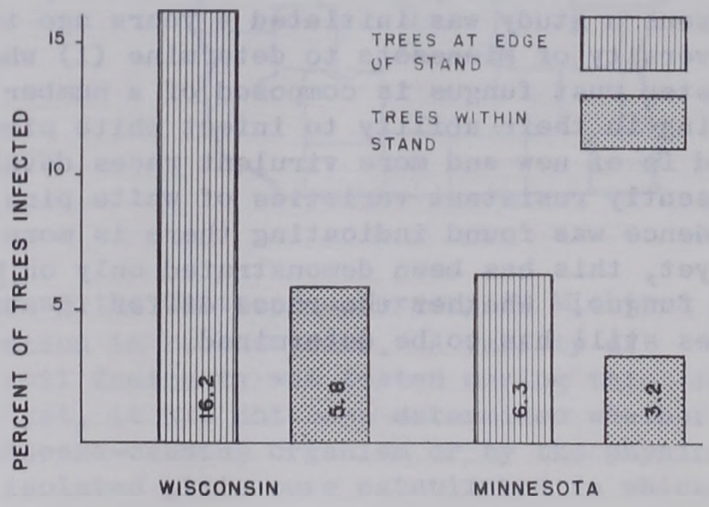
Forest Diseases

Forest disease research during 1954 has been directed chiefly toward the following studies:

Factors Influencing the Incidence of Hypoxylon Canker of Aspen

This study, now 6 years old, has been carried on with the active participation of the pulp and paper industry in the Lake States. During 1954 further studies were made of the importance of stand density and tree stem exposure. Previous work had indicated that these factors show a correlation with the incidence of Hypoxylon--the more open and exposed stands showing more infection. This past year, several sets of thinning plots were

THE INFLUENCE OF TREE EXPOSURE ON HYPOXYLON CANKER OF ASPEN



ON BASIS OF A PAIRED 600 TREE SAMPLE FOR EACH CONDITION IN EACH STATE

established throughout the Lake States in order to study further the importance of these factors. In cooperation with the Iron Range Resources and Rehabilitation Commission, a 40-acre stand of aspen in northern Minnesota was selected for an intensive study of exposure and density. A considerable number of previously established permanent sample plots have been re-examined. These data should provide better information on impact of the disease on aspen productivity.

Further work on the problem of determining the mode of infection was carried on during 1954. Again all attempts to produce infection by wounding and inoculation of the trees with Hypoxylon spores gave negative results. Present evidence seems to indicate that the presence of dead branch stubs is important. It also appears possible that factors such as the microenvironment of a wound may play an important role in the establishment of infection.

Plans for 1955

Hypoxylon studies will proceed along several lines. Studies of stand density and exposure will be continued with emphasis on remeasurement of the older established studies rather than establishment of more plots. Emphasis will be placed on studies of artificial infection of aspen in order to discover the necessary conditions for the establishment of Hypoxylon. This information is badly needed as a basis for evaluating plot data and developing practical control measures. A considerable volume of accumulated plot data will be analyzed and evaluated.

Races of White Pine Blister Rust

Considerable interest and effort are being directed toward developing varieties of white pine that are resistant to blister rust infection. Some success has attended these efforts. Many fungi, however, are able to develop new races or varieties, which differ in their abilities to infect plants. Furthermore, a new race may be introduced from a foreign area. In either case, plants at present considered resistant may at any time be attacked by a new race or variety of a fungus. For these reasons a study was initiated 4 years ago in cooperation with the University of Minnesota to determine (1) whether or not the white pine blister rust fungus is composed of a number of races or varieties differing in their ability to infect white pines, and (2) what the likelihood is of new and more virulent races developing that might infect presently resistant varieties of white pine. This year, additional evidence was found indicating there is more than one race of the fungus. As yet, this has been demonstrated only on Ribes, the alternate host of the fungus. Whether the races differ in ability to infect the white pines still has to be determined.

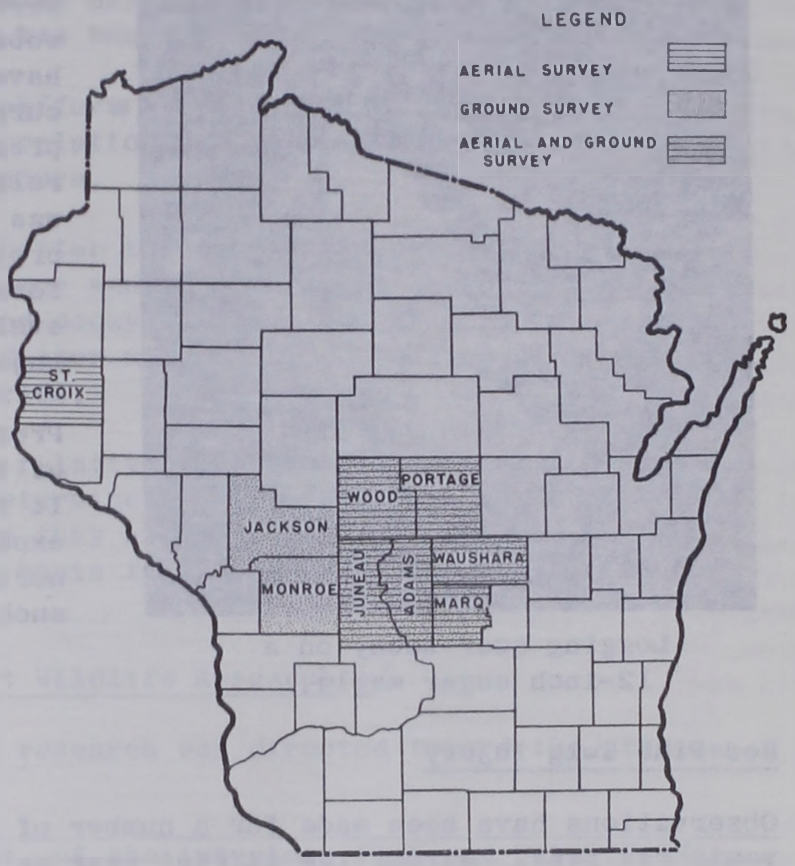
Plans for 1955

Further tests will be made to obtain more replications of the present studies on Ribes. In addition, it is planned to begin studies on the white pines to test their susceptibility to the different races.

Oak Wilt Survey

Oak wilt has been present in the Lake States region for a longer period of time and is more prevalent than in any other part of the country. For these reasons, the region was selected for conducting an oak wilt-damage survey. The purpose of the survey was to determine potential impact of the disease on the oak type. This season's survey was a continuation of a similar survey made in 1953. In 2 years a 6-county block in central Wisconsin was covered by both aerial reconnaissance and regular ground survey plots, 2 counties by ground survey only, and 1 county by aerial reconnaissance only. Results show that approximately 2 percent of the oak type in these counties is infected. In the counties surveyed about one-fourth of 1 percent of the total oak volume is being lost annually due to the disease.

COUNTIES SURVEYED FOR OAK WILT DAMAGE IN WISCONSIN



Present plans call for a continuation of this survey into southern Minnesota during the summer of 1955.

White Pine Root Rot

The white pine root rot problem at the Chittenden Nursery in Michigan has received considerable attention in recent years. A variety of fungicides, insecticides, and soil fumigants was tested during this time with inconclusive results. As yet, it has not been determined whether the root rot is induced by a disease-causing organism or by the physical environment. This past year, isolated plots were established in which

the soil was treated with several chemicals. Tests were also conducted using various shading and watering schedules. No results were obtained, however, as the incidence of the disease was so low this past year that neither the treated nor untreated plots became infected. These studies will be continued during 1955. In addition, a seed-source study and a fungicide seed-pelleting study are planned as possible solutions to this problem.

Defect in Northern Hardwoods

In 1952, a study of defect in hard maple was initiated at the Dukes Experimental Forest in upper Michigan to determine (1) the amount of decay and degrade caused by various types of old logging injuries, and (2) the important decay organisms involved. Only trees from stands partially cut at a known time in the past were selected for study. The woods and mill dissection data have been collected and are currently being analyzed and prepared for publication. A relatively small-scale study was incorporated into the project in 1954 in which different logging practices were evaluated as to the amount of injury to residual trees.

Logging scar decay on a 12-inch sugar maple.

Present plans for continuation of this work are indefinite. It is hoped that work can be expanded to include other northern hardwood species, such as yellow birch.

Red Pine Twig Injury

Observations have been made for a number of years on a twig injury of young red pine. During the current year no evidence of new damage was noted. Plans are to continue observations on this disease.

Black Spruce Dwarf Mistletoe

With the cooperation of the University of Minnesota, data were collected on a number of permanent plots set up 6 years ago to study the black spruce dwarf mistletoe. The objective of this study is to determine the rate of spread of infection centers, the rate of deterioration of

infected trees, and effectiveness of various control measures. Analysis of available data should provide some practical information concerning control of this disease.

No definite plans have been made for future work on this problem. There is need, however, for the establishment of control studies on a pilot scale.

Other Research Needed

No new projects are planned for 1955 as continuing work on established studies will require all the attention of the present staff. There are, however, other disease problems in the region which should receive attention. Some of the more important are as follows:

Plantation diseases.--In addition to recognized problems, such as the Armillaria root rot of red pine, there is a need for evaluation of general disease problems, especially in the older plantations; these are now approaching the age at which difficulties have been encountered in other regions where forestry has been practiced for many decades.

Bacterial wetwood of aspen.--Efforts should be made to determine the distribution of wetwood, its relationship to various environmental factors, and how infection occurs.

Defect and decay.--More and better information is needed on the relationship between site conditions and management on the one hand, and the development of defects and decay for many of our more important tree species on the other. Better methods for detection of rotten cull are also needed for many species.

General disease survey.--The relative prevalence and impact of the various diseases should be determined so that research and control efforts can be directed where they are most needed. This information would also provide a factual basis for incorporating a disease loss factor in growth predictions.

Forest Wildlife Research 1/

During 1954, forest wildlife research was directed toward the studies discussed below.

1/ Conducted by the U.S. Dept. of the Interior, Fish and Wildlife Service. The material included in this report was prepared by the biologist assigned to the Lake States Station by the Section of Wildlife Investigations on Public Lands, Branch of Wildlife Research. Research is conducted under cooperative agreements with the Forest Service, the National Park Service, the Office of Indian Affairs, the Quetico-Superior Wilderness Research Center, and the Branch of Refuges of the Fish and Wildlife Service.

Effect of White-Tailed Deer and Snowshoe Hares on Range Recovery

In 1949, four exclosures for deer and snowshoe hares were established on the Lower Michigan National Forest; two more were added in the spring and fall of 1952. During 1954, the vegetation was tallied in all six of the exclosures, although the findings for only the four older ones have been summarized. In an exclosure on a jack pine plantation (planted to 2-0 stock in 1947 and 1948), the protected seedlings suffered no mortality; the average height growth per tree was 4.4 feet, and the feet of live stem increased by 652 percent in 5 years. In contrast the unprotected seedlings suffered 37 percent mortality, the average height growth per tree was 2.4 feet, and the feet of live stem increased by 263 percent. All of the mortality and height reduction may be attributed to deer browsing as no hare damage has occurred so far.

In an exclosure in a mixed coniferous swamp, the number of stems of tree reproduction and shrubs increased by 51 during the years 1951-54, while there was an increase of only 3 on the unprotected plot. The stems of white-cedar, a preferred species, increased from 15 to 26 inside the exclosure, but remained the same on the control. The total feet of height growth per milacre plot increased 7 feet within the exclosure but only 6 feet outside of it. Both deer browsing and snowshoe hare clipping have been noted on the control plot.

In another exclosure in a mixed conifer swamp, the number of stems increased by 72 versus only 24 on the control plot. There was 182 percent more feet of live stem inside the exclosure in 1954 than in 1949; outside the fenced area there was 29 percent less. Some of the greatest increases were shown by red maple and elderberry, which are among the preferred deer foods.

An exclosure at the edge of a mixed conifer swamp showed an increase of 16 stems per milacre plot within the exclosure and a decrease of 7 outside (1951-54). During the same period, the total feet of height growth per milacre plot increased by 4.4 in the deer-proof section, 35 in the deer- and hare-proof part, and decreased about 6.5 feet on the control area. Again the plants in the unfenced area were subjected to both deer and snowshoe hare damage.

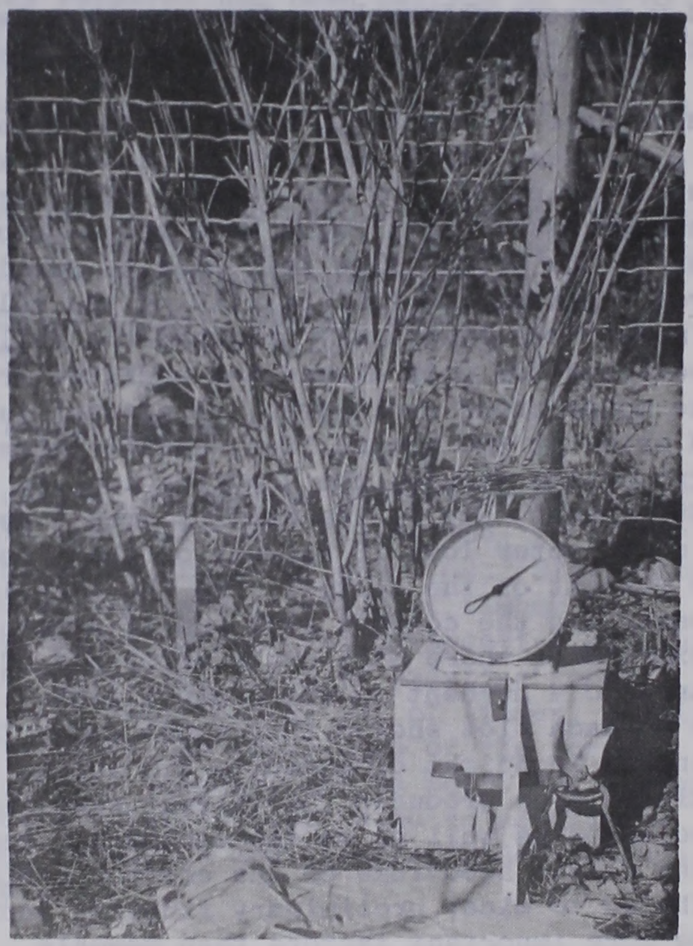
Results of Controlled Deer Hunts on the Mud Lake National Wildlife Refuge

This 93-square-mile refuge in northwestern Minnesota has been open to hunting with firearms for 5 years (1949 and 1951-54). Each year, in conjunction with the opening of the state season, a special season has been held on the same area of approximately 31 square miles. Data gathered at checking stations showed that: (1) during five open seasons 4,750 hunters bagged 1,417 deer for an average success ratio of 30 percent; (2) fawns made up from 41.4 to 47.9 percent of the kill; (3) the fawn-per-doe ratio was high, ranging from 136 to 179 fawns per 100 does; (4) after 5 years of hunting, the sex ratio became even for the adults and almost even for the fawns; (5) based on 1,300 deer, the average weight of adult males

decreased from 185 pounds in 1949 to 155 pounds in 1954; weights of the adult females showed no trend but ranged from 128 to 136 pounds; the male fawns ranged from 72 to 83 pounds; and the female fawns ranged from 67 to 77 pounds; (6) age information (1951 and 1952) on adults ($2\frac{1}{2}$ years and older) showed that the average age of male deer increased from 2.7 to 3.9 years, while there was a slight drop in the age of females from 3.9 to 3.7 years.

Deer Range Appraisal on the Necedah and Tamarac National Wildlife Refuges

An appraisal of the range on the 62-square-mile Necedah Refuge in central Wisconsin was taken this year with two major objectives in mind: (1) to obtain information on the distribution and density of the browse species and the extent of deer browsing, and (2) to determine any changes in range conditions by comparing the appraisal results with those for 1950. Most plants present in 1950 appeared in more of the plots in 1954. Also, preferred species such as chokeberry, wintergreen, elderberry, red osier dogwood, and sumac appeared in the 1954 tally but were absent in 1950. Plant distribution had increased by 45 percent and the density by 131 percent. The indexes of browsing were low in 1950 and dropped still lower in 1954. The indexes of 5 of the species decreased as follows: jack pine, 6 percent; aspen, 10 percent; oak, 3 percent; willow, 10 percent; and juneberry, 11 percent. Such a rapid recovery of the range indicates that the deer herd has been held at carrying capacity level or lower.



The annual growth of the mountain maple clump in the background was clipped artificially and weighed in a study aimed at determining the amount which may be browsed by deer and still permit the plant to recover in a satisfactory manner.

An appraisal on the Tamarac Refuge in northwestern Minnesota had like objectives in mind. Again, most plants present in 1950 appeared in more of the plots in 1954. Also, alternate-leaved dogwood, arrow wood, red maple, and leatherwood appeared in the 1954 tally for the first time. For the refuge as a whole, plant distribution increased by 46 percent. Five sample units had increased densities, and 3 had decreases; the density on all areas, however, decreased 7 percent. The index of browsing for the refuge as a whole dropped 72 percent, and the indexes for 5 of the species decreased as follows: hazelnut, 19 percent; red osier dogwood, 58 percent; cherry, 27 percent; willow, 20 percent; and bur oak, 19 percent. The 1954 findings show the range has improved slightly, but continued herd reduction is needed before satisfactory range conditions can be expected.

Effect of Mammals on Yellow Birch Seedlings

This study was started on the Upper Peninsula Experimental Forest (Dukes, Michigan) in the fall of 1953. The objectives were to appraise the importance of mammals such as field mice, shrews, snowshoe hares, chipmunks, red squirrels, and white-tailed deer in retarding or prohibiting the establishment of yellow birch reproduction. A small mammal trap line was established and resulted in a 20-percent catch in the fall of 1953, 4.7 percent in the spring of 1954, and 3.6 percent in the fall of 1954. The species composition of 3 trapping seasons was 38.4 percent woodland deer mice, 51.2 percent red-backed mice, 6.4 percent shrews, and 4.0 percent chipmunks. Stomachs have been saved for later examination to determine the presence or absence of yellow birch seeds.

Another phase of the study required the establishment of 8 exclosures (3 x 3 x 2 feet high) and control plots (3 x 3 feet) within the disked and undisked portion of the 20-acre study area. Four of the exclosures ($\frac{1}{2}$-inch hardware cloth) were made mouse-proof and 4 had about 2 to 3 inches at the ground line left open to permit mice to enter if they so desired. Spring and fall tallies of the yellow birch seedlings have been made. The fall tally produced the following results: The number of seedlings for both disked and undisked areas had decreased 23 percent in the mouse-proof exclosures, 14 percent in the exclosures where mice could enter at the ground line, and 13 percent on the control. Where the ground was disked, the seedling loss in the mouse-proof exclosure was 29 percent, and in the control area 9 percent; the exclosures which mice could enter lost 10 percent of their seedlings compared to a loss of 18 percent on the control. On the non-disked area, the mouse-proof exclosure and the control each had 16 percent less seedlings, whereas the exclosures where mice could enter had 22 percent less seedlings compared to 4 percent on the control plots. Twenty-five marked seedlings on each plot showed that those under the hardware cloth averaged 2.8 inches in height compared to 2.0 inches for the control, and that the disked area produced the tallest seedlings within the two kinds of fenced areas as well as on the controls. Deer nipped 13.3 percent of all the marked seedlings on the control plots. So far, no damage can be attributed to mice; preliminary findings indicate that light and moisture may be more important factors than mammals.

Other Research Projects

Other research projects in 1954 included (1) a study of silvicultural practices in mixed coniferous swamps in relation to the establishment of tree reproduction and shrubs of value to deer and other wildlife, and (2) a study of birds and mammals in relation to the establishment of tree seedlings and other woody plants following fire in a mixed conifer type.

Plans for 1955

Work will be done on all of the projects listed with the exception of the study of deer range appraisal results on the Necedah and Tamarac National Wildlife Refuges. The study of effect of white-tailed deer and snowshoe hares on woody vegetation will be expanded to include a retally of the vegetation in the exclosures on the Tamarac Refuge and the Chippewa and Superior Forests. Also, the pilot tests on the effect of herbicide and fuel oil sprays on top kill and resprouting of mountain maple will be expanded. To be published soon is a summary of the results of controlled deer hunts on the Tamarac Refuge. Similar information on Mud Lake Refuge deer will also be published.

FOREST ECONOMICS

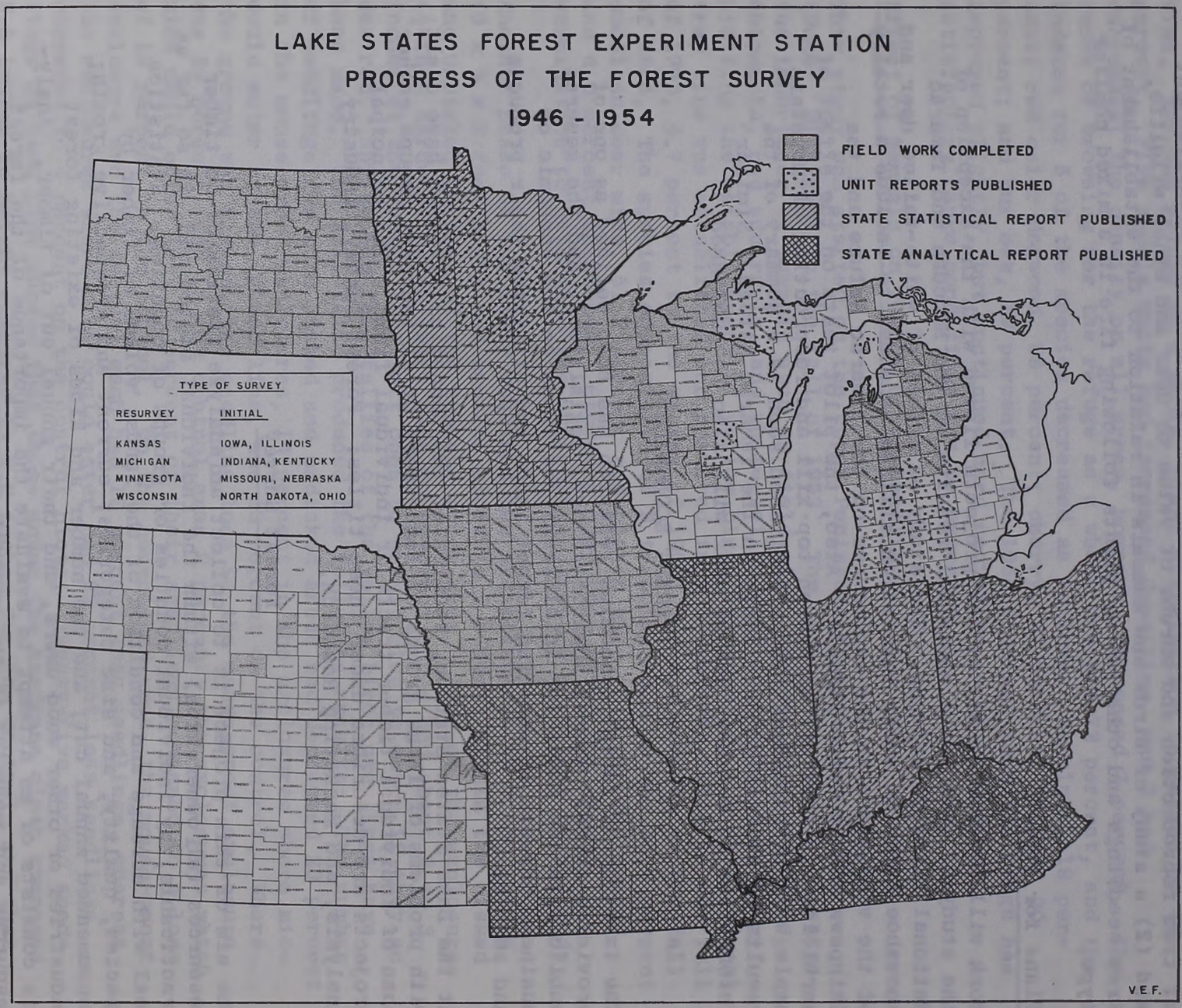
The function of forest economics research has been defined as one of providing forest owners, administrators, legislators, and the general public with the basis for intelligent decisions on the economic or business aspects of managing forest lands and utilizing their products and services.

At the Lake States Station, studies of the Economics Division have dealt with problems of large groups of landowners or of industry groups rather than of individual timber tracts or individual firms. The principal projects are described under these titles: Forest Survey, Industry Analysis, and Marketing Research.

Forest Survey

The aim of this project is to collect and analyze statistics on timber resources (all ownerships) within the individual states and, in so far as practicable, by individual counties or groups of counties. Statistics deal with acreage and condition of the lands; volume of timber by species, quality, and size categories; current and prospective growth; recommended annual cut; and the number and kinds of existing forest industries or other wood users, and their annual cut of timber. Analysis consists of an attempt to evaluate the importance of the forest resources and industry in the general economy, and to point out elements of imbalance in the cut and growth relationships; also to consider probable future trends in forest resources and industry under various alternatives of resource management.

LAKE STATES FOREST EXPERIMENT STATION
PROGRESS OF THE FOREST SURVEY
1946 - 1954



The responsibility for conducting the forest survey of Ohio, Indiana, Illinois, Kentucky, Iowa, Missouri, Nebraska, and Kansas was transferred to this Station during the year. The move was designed to reduce overhead and increase efficiency. The status of the survey is shown by the accompanying map and table, and discussed for those states where work is under way.

Status of the Forest Survey, December 31, 1954

State	Forest area	Proportion of job done		
		Total job	Field inventory	Reports
	M acres	Percent	Percent	Percent
Initial Survey:				
Illinois	3,996	100	100	100
Indiana	4,103	99	100	50
Iowa	2,248	59	100	0
Kentucky	11,497	100	100	100
Missouri	15,187	100	100	100
Nebraska	1,112	16	24	0
North Dakota	433	61	90	0
Ohio	5,446	88	100	40
Maintenance Survey:				
Kansas	1,121	13	25	0
Michigan	19,300	57	78	21
Minnesota	19,344	90	100	70
Wisconsin	16,500	43	66	2
All States	100,287	77	88	53

Forest Statistics for Minnesota Published

In Minnesota, participation of a number of state, federal, and private agencies permitted a more than usually detailed and accurate survey of resources. Field work was completed early in 1954 and a brief state statistical report was released late in the year.

The report shows that during the period between the 1936 survey and the one just completed the volume of timber stands increased noticeably. Although volumes of softwood sawtimber dropped 20 percent, hardwood sawtimber volumes increased 51 percent. Volumes of softwood pulpwood are about the same as 17 years ago, but aspen pulpwood volumes are now about 50 percent greater.

Poletimber and sawtimber stands have increased substantially in area. The acreage of nonstocked land also has increased slightly, however, and softwood types have decreased somewhat in area.

The rate of timber cut increased since 1936. The cut of lumber and veneer logs rose 29 percent, and pulpwood and excelsior rose 146 percent. Fuelwood cut, on the other hand, dropped 17 percent.

The state statistical report also indicates that, without reducing the productivity of its forests, more timber of some species could be harvested in Minnesota than was cut in 1952. Improved protection against fire and other factors has created a favorable balance of growth over volume cut. Most of the potential increased cut, however, is tamarack, cedar, aspen, and other low-quality hardwoods, rather than the preferred spruce or pine. Most of the available timber also is located in rather sparse or inaccessible stands.

The Iron Range Resources and Rehabilitation Commission, principal collaborator in the Minnesota Survey, is publishing a series of detailed county and district reports. During the year it issued three such reports, one for Becker County, one for Lake of the Woods County, and one for the 11 lightly timbered counties in the Red River Valley.

The Station is preparing an analytical report in which Minnesota forest statistics will be more fully explained and interpreted.

Survey Moves Along in Other States

The Wisconsin forest inventory also has been greatly intensified and localized by the work of the Conservation Department, the counties, and the forest industries. The first two individual county reports, covering Waupaca and Waushara Counties, were published by the Wisconsin Conservation Department late in the year. Seven other reports are undergoing review or being published. Ten or 12 county reports will be released during 1955. Unfortunately, new field work has been delayed due to failure of contractors to deliver new aerial photography in several counties.

The post-war inventory of Michigan's forests was begun in 1946, and field work should be completed in 1956. This survey is designed to give detailed county information. Outside of national and state forests, the work has been done by a 3-man crew, one man each being provided by the Michigan Conservation Department, the American Box Board Company, and the Station. The Station has done most of the computing. During 1954 field work was completed in nine counties in the northern part of the Lower Peninsula. Early in 1955 field work will begin in the eastern end of the Upper Peninsula. The Conservation Department published a report on timber resources of Dickinson and Iron Counties in 1954. Reports covering about 20 additional counties are scheduled for 1955.

The inventory of native woodlands of North Dakota was completed in 1954. A statistical report is scheduled for 1955. Further surveys of windbreaks and shelterbelts, which are highly important in this state, are needed but probably cannot be undertaken in 1955.

Field work on the inventory and a survey of timber production in Iowa were completed in 1954. The survey was done at twice the intensity required by national standards, thanks to the cooperation of the Iowa Conservation Commission and the Agricultural Experiment Station. Computations are under way in St. Paul. Forest statistics will be reported for three major geographic divisions of the state during 1955.

The inventory of Nebraska is being undertaken during the first 6 months of 1955 by one man from this Station and one man furnished by the Agricultural Experiment Station. Concurrently the Extension Forester is making a study of timber production. A similar cooperative study in Kansas will be undertaken at some later date. Statistical reports will be prepared for each state.

Field work and computing have been completed and unit reports released for both Indiana and Ohio. The state statistical report for Indiana was published in January 1953. The analytical report was prepared during the past year and will soon be published. A state statistical report for Ohio is scheduled for preparation and release in 1955.

Timber Cutting Studies a Part of Forest Survey

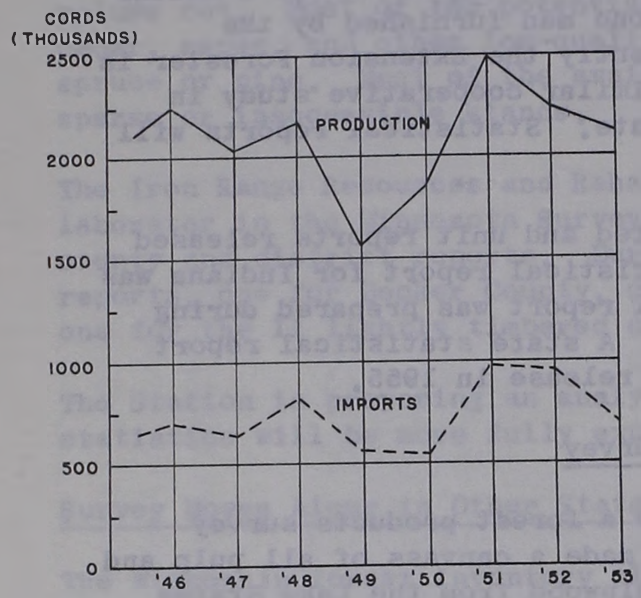
Pulpwood survey.--Functioning according to a forest products survey schedule established in 1946, the Station made a canvass of all pulp and miscellaneous fiber mills that obtained pulpwood from the Lake States region in 1953. Fifty-four pulp mills were contacted in 1954, of which only one was a nonresident plant. Detailed information on species and geographic origin of logs and bolts by states was obtained for each pulp mill.

Production figures collected since 1946 are beginning to show some important trends in industrial use. High levels of pulp and paper output have been made possible to a large extent through greater use of aspen and dense hardwoods. The peak of pulpwood production was attained in 1951 when about $2\frac{1}{2}$ million cords of pulpwood were cut in the Lake States (see pulpwood graph). With increasing use of hardwood species even higher production levels are possible.

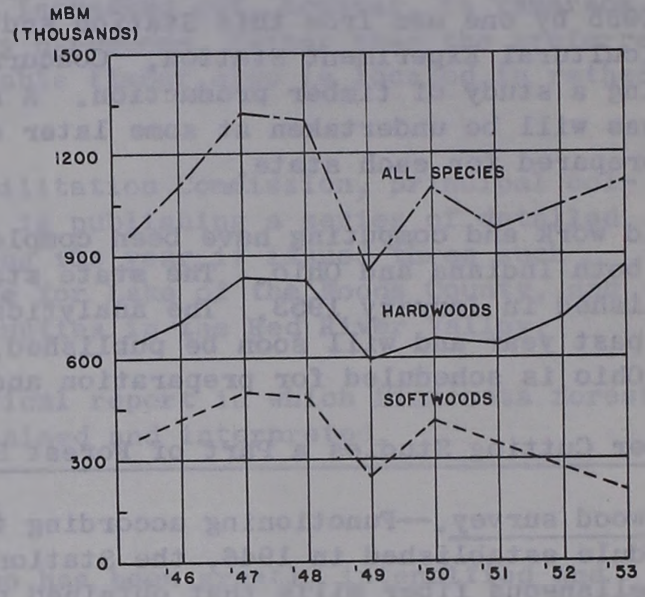
Lumber survey.--As a collaborator with the Bureau of the Census, the Station in 1954 actively participated in the collection of data on lumber production for the years 1952 and 1953 in selected sample areas in the Lake States. The work consisted of locating all sawmills in each of these sample segments and obtaining lumber production data from each mill operator. These data and those collected by the Bureau of the Census were used to provide softwood and hardwood lumber production estimates for the years 1952 and 1953 in the region. The annual cut of

timber in the Lake States has averaged slightly more than one billion board feet since World War II. The largest output was recorded in 1947 when about 1-1/3 billion board feet of lumber were cut (see lumber graph). In recent years there has been a noticeable downward trend in softwood production counteracted by an increase in the production of hardwood lumber.

The production of lumber and other primary products in Iowa and Nebraska was determined by field surveys made in cooperation with the State Agricultural Experiment Station. Special mill studies were made in Iowa to determine utilization factors such as mill overrun, log grade distribution of sawtimber cut, percentage of lumber cut from non-forest land, etc.



Pulpwood production and imports, Lake States, 1946-53



Lumber production, Lake States, 1946-53

Fuelwood and fence post cutting.--State forest survey agencies collected data on fuelwood and fence post production for 1953 in 35 Minnesota, Wisconsin, and Michigan counties. These data provide a basis for estimating statewide production of fuelwood and fence posts. The samples indicate that the 1953 cut of fuelwood in Minnesota amounted to about 1,100,000 cords, of which about 800,000 cords was cut by farmers, and 300,000 cords by resort owners, other forest residents, and mill operators.

Minnesota's harvest of fence posts in 1953 was approximately 8 million pieces. Here again farmer production was much larger than that of other producers, amounting to about three-fourths of the total cut. Oak accounted for most of the cut in the southern counties while cedar, aspen, and tamarack were the preferred fence post species in the northern part of the state.

Utilization study.--A study was designed by the Station to collect current information on the logging residue that results from cutting the major forest products. Such data were needed in order to provide reliable timber cut figures for the Timber Resource Review project and regular forest survey work.

Going logging operations were studied in 15 different logging areas. A total of 500 felled trees were measured on the study areas. The cull, merchantable volume, and waste sections were diagrammed and recorded for each sample tree. Damage to surrounding timber was also recorded. Preliminary results of the study indicate some improvement in cutting practices in most areas over those of 10 or 15 years ago.

Keeping the Survey Up To Date

A problem of major importance in both the Central and Lake States is how to keep forest inventory data up to date between field surveys which may be 10, 12, or 15 years apart. Basically, the need is to obtain reasonably accurate estimates of timber cutting and other losses year by year (drain), improved estimates of annual growth, and a reasonable number of permanent plots on which net change can be observed from time to time.

As with the current inventories, the maintenance of up-to-date resource records will need to be a cooperative undertaking among private, state, and federal agencies. Preliminary planning is under way in states where initial surveys have been or are about to be completed.

Industry Analysis

Resource statistics such as obtained on forest surveys find one of their most significant uses when applied to the problems of some of the major forest industries.

In the Lake States, the pulp and paper industry is confronted with some very serious problems of wood supply. Over the years, the best supplies of mature spruce, pine, hemlock, and other softwoods, upon which the industry was originally founded have been progressively depleted. This has not halted the growth of the domestic industry, but it has forced it to rely more and more upon costly imported wood to the detriment of its competitive position.

Solutions of a local nature are possible by the stimulation of new softwood timber growth on the one hand, and partial conversion of industry to the use of hardwoods on the other. Both developments can be guided more intelligently with the aid of good figures on type acreages, growth potentials, drain trends, and related resource information.

The Station has undertaken to assemble the best data available on these subjects, and plans within the year to publish a report incorporating its analysis of the potentialities of timber supply under several feasible programs of resource management.

Marketing Research

Need for intensive study of markets for forest products has long been recognized, and several forest research groups in the Lake States are beginning some studies in this field. The recent allotment of funds to this Station permits the initiation of a modest program.

Twin Cities Hardwood Market Study Under Way

During 1954 the Station, in cooperation with the University of Minnesota, inaugurated a study of the market for hardwood products in the Twin Cities. Criteria for the choice of products were: (1) that they represent the utilization of significant quantities of hardwood lumber, (2) that they can be fabricated from species prevalent in Minnesota, (3) that they are commonly constructed from lower grades of lumber, and (4) that their market is stable or expanding. Two groups of products rated high on this scale of measurement--wood pallets for materials-handling, and boxes and crates.

The Station singled out the pallet industry for investigation of production, distribution, and consumption. Manufacturing plants supplying the Twin Cities were located in order to analyze production, procurement, and investment factors which affect the marketing processes. The study followed the channels of distribution, exploring the methods and practices as it progressed. Development of patterns and trends of consumption completed the market analysis. Throughout the inquiry particular attention was devoted to difficulties associated with production and distribution, the elimination of which would provide for smoother functioning within and between the several phases of the marketing process.

Nationally, the pallet industry is the sixth largest consumer of hardwood lumber used in manufacture, the volume thus consumed having trebled since World War II. The production of pallets has grown rapidly in this region. Minnesota and Wisconsin trail Michigan, which leads the industry. Though using only 4 percent of all hardwood lumber further manufactured in Minnesota, pallet production assumes more significance to the wood industry as a market for over 15 percent of grade 3 Common hardwood. Most of the locally manufactured pallets are sold in the Twin Cities; but this market is also supplied by producers from the other Lake States as well as by others as far away as Alabama, Kentucky, and Arkansas. The study may throw light on means by which suppliers near this market can increase their share in it.

Major Marketing Problems Concern Low-Grade Hardwoods

The problem of disposing of vast quantities of low-grade hardwood is of great concern in this region. The 15.5 billion cubic feet of hardwoods, mostly second growth, contains a large proportion of inferior species and of poor-quality scrubby trees which should be removed. This is particularly true toward the south where not more than 16 percent of the

total oak volume is in No. 1 logs. Minnesota's position relative to hardwood sawtimber is probably the poorest of the three states. The trees run somewhat shorter and carry more cull. Furthermore, there is a smaller proportion of sugar maple and yellow birch. Of the hardwood sawtimber volume, 25 percent is in oak, 25 percent aspen and cottonwood, and 15 percent elm. More than half of the lumber in Minnesota's hardwood sawtimber trees is estimated to be grade 3 Common or poorer.

The problems concerning aspen differ somewhat from those of other hardwoods. In some localities excellent markets exist; in others, there is no market. The problem will need to be approached on a local basis. Jack pine, too, presents serious problems in some localities. Such cases suggest opportunities for cooperative projects with national forests and other owners in specific problem areas.

It seems likely that marketing research can make its largest contribution by analyzing consumer demands. This region and adjoining states contain one-fourth of the United States population and help supply large consuming centers such as Detroit, Chicago, Milwaukee, and the Twin Cities. Analysis of existing wood consumption habits and the attitude of users toward various types of products which can be made of Lake States timber should lead to more intelligent manufacturing and selling on the part of producers.

PUBLICATIONS IN 1954

(Arranged by Subject Matter)

Forest Management, Silviculture

Arend, John L.

*Effects of season in Michigan on control of hardwoods with frill girdles and 2,4,5-T. North Cent. Weed Control Conf., 11th Ann. Report, p. 130. (Processed.) 1954.

(Tests indicate that frill girdling of unwanted hardwoods with 2,4,5-T esters in oil during the summer and fall in lower Michigan will result in better control with less vigorous sprouting than at other seasons of the year.)

*Some effects of 2,4-D and 2,4,5-T ester foliage sprays on conifers. North Cent. Weed Control Conf., 11th Ann. Report, p. 130. (Processed.) 1954.

(Most conifers in northern lower Michigan can be treated in brush control and release operations during August with foliage sprays of 2,4-D and 2,4,5-T esters at rates of 2 lbs. of acid in 5 gal. water per acre without serious damage.)

*Publications marked by asterisk are not available for distribution by the Station.

Heinselman, M. L.
Thinning from above reduces total yields in medium site aspen. L.S. Tech. Note 411, 1 p. (Processed.) Jan. 1954.
(Describes commercial thinnings taken from the upper crown classes in 30-year-old medium site aspen, which produced early returns, but reduced total yields when the stand reached rotation age.)

Hesterberg, Gene
Cull in sugar maple increased by breakage of large limbs during logging. L.S. Tech. Note 417, 2 pp. (Processed.) Apr. 1954.
(Evaluates the amount of cull volume and type of defect resulting from breakage of large limbs in residual sugar maple trees caused by logging damage in partial cutting operations.)

Lake States Forest Experiment Station
Thinning aspen woods will pay. For. Ind. Information Committee of Minn., For. Bul. 4, 4 pp., illus. May 1954.
(Describes benefits to be gained by intensive management of young aspen on good sites.)

Ralston, R. A.
Some effects of stand density on the height growth of red pine on poor sites in northern lower Michigan. Mich. Acad. Sci., Arts, and Letters. Papers 39: 159-165. 1954. (1953 meeting.)
(On poor sites in northern lower Michigan, after 35 years, the dominant red pine trees in a plantation spaced 4 x 4, 6 x 6, 6 x 8, and 8 x 9 feet averaged 25.4, 27.8, 29.8, and 31.5 feet in total height respectively.)

_____
Timing and yields of first commercial thinnings in red pine plantations. L.S. Tech. Note 420, 1 p. (Processed.) Oct. 1954.
(First commercial thinning recommendations, based on 3 experimental thinning operations in lower Michigan, are: (1) thin from "below" except for defective trees; (2) thin so that the average spacing between trees after cutting is 25-30 percent of the average stand height; (3) leave well formed, vigorous trees at the rate of 80-100 sq. ft. of basal area per acre; or (4) leave 500-600 trees per acre well distributed throughout the plantation.)

_____, and Coulter, L. L.
Aerial spray tests with 2,4,5-T for scrub oak control in lower Michigan. L.S. Tech. Note 424, 1 p. (Processed.) Oct. 1954. Also North Cent. Weed Control Conf., 11th Ann. Report, p. 135. (Processed.) 1954.
(Three-year results reveal that the tops of scrub oak in northern lower Michigan can be killed with little to no sprouting and with no damage to underplanted red pine by aerial sprays during August with 1 lb. of 2,4,5-T ester acid equivalent in 1 qt. of fuel oil and 8 qts. of water per acre.)

Roe, E. I.
*Forest research center studies growing balsam pulpwood. Lake States Timber Dig. 7 (10): 5,8. March 1954.
(A brief resume of the balsam fir management studies being carried on at the Headwaters Research Center.)

---

*Aerial spraying to release planted spruce from overtopping hardwoods. North Cent. Weed Control Conf., 11th Ann. Report, p. 136. (Processed.) 1954.
(The spraying killed or severely defoliated 85 percent of the pole-sized birch, thus giving full or partial release to about 80 percent of the white spruce.)

---

*Herbicide spraying very effective in freeing pines from overtopping brush. North Cent. Weed Control Conf., 11th Ann. Report, p. 136. (Processed.) 1954.
(Four years after spraying, only 18 percent of the planted and natural pine seedlings need low release compared to 83 percent on the adjacent unsprayed area.)

---

*Spraying hazel with herbicides aids establishment and growth of pine reproduction. North Cent. Weed Control Conf., 11th Ann. Report, pp. 135-136. (Processed.) 1954.
(As a result of killing back of brush, the number and size of pine seedlings present has greatly increased, and they are in less need of release than those where no spraying was done.)

Zasada, Z. A., Heinselman, M. L., and Voigt, G. K.
Potential productivity of forest lands in Pine, Carlton, Aitkin, and southern St. Louis Counties, Minnesota. (In cooperation with Iron Range Res. & Rehab.) L.S. Misc. Report 30, 53 pp., illus. (Processed.) 1954.
(Describes the history, present condition, and problems of the forest lands in the counties, and suggests an improvement program.)

Regeneration (Seed, nursery, planting, tree improvement)

Rudolf, Paul O.
*The Lake States Forest Tree Improvement Committee. Proc. 1st N.E. For. Tree Impr. Conf. pp. 97-98, 1953. (Processed.)
(Briefly outlines organization and work of the Committee.)

Fair 1953 forest tree seed crop in the Lake States. L.S. Tech. Note 412, 2 pp. (Processed.) Jan. 1954.
(Reports the estimated percentage of a full seed crop of the more important forest tree species in northern Minnesota, northern Wisconsin, central upper Michigan, and lower Michigan.)

_____. Forest tree improvement work in the Lake States. Jour. For. 52 (9): 688-689. Sept. 1954.

(Very brief resume of past work and current status of forest tree improvement research in the region.)

_____. Age of seed tree and earliness of shoot growth in young red pine seedlings. L.S. Tech. Note 422, 1 p. (Processed.) Oct. 1954.

(Nursery observations of 160+ lots of red pine seedlings indicate that progeny of very old or very young trees generally are slower in starting terminal shoot growth than those of intermediate age.)

_____. Seed source and earliness of shoot growth in young red pine seedlings. L.S. Tech. Note 423, 1 p. (Processed.) Oct. 1954.

(Nursery observations on 160+ lots of red pine seedlings indicate a general relationship between earliness of beginning shoot growth and length of growing season of the place of seed origin.)

Mensuration (Growth, volume, yield, sampling)

Baten, W. D., and Arend, J. L.
A laboratory study of various systematic sampling methods applicable to forest-regeneration surveys. Mich. Acad. Sci., Arts, and Letters. Papers 39: 113-123, illus. 1954. (1953 meeting.)

(The systematic sampling of seed scattered on a chart by methods commonly used to sample forest reproduction revealed that no particular method was reliable for estimating quantity when the area sampled was less than 4 percent. Estimating stocking, however, was more accurate when only 1 percent of the area was sampled.)

Gevorkiantz, S. R.
The Lake States cruising stick. L.S. Tech. Note 409, 2 pp., illus. (Processed.) Jan. 1954.

(Explains the construction and use of a simple hypsometer for estimating total and merchantable heights on standing trees. The instrument does not require measuring horizontal distances.)

Forest Protection

a. Fire

Mitchell, J. A.
Lake States forest fire damage tables for young second-growth stands. L.S. Misc. Report 27, 6 pp. (Processed.) Mar. 1954.

(Presents revised tables for estimating fire damage which permit the use of current local stumpage rates.)

_____
Rating the effectiveness of forest fire protection. Jour. For. 52: 183-185, illus. Mar. 1954.

(The effectiveness of protection effort cannot be judged by number of fires and areas burned alone, since conditions vary from year to year and from place to place. One approach to the problem is presented here through a partial analysis of available records on the Chippewa National Forest.)

_____
Mortality from fire in jack pine stands. L.S. Tech. Note 416, 2 pp., illus. (Processed.) Apr. 1954.

(Discusses the variation in mortality from fire in jack pine stands, depending on kind of fire, character of stand, and prevailing conditions.)

_____
Some thoughts on forest fire damage appraisal. L.S. Misc. Report 29, 4 pp. (Processed.) May 1954.

(Discusses the problem of what constitutes fire damage and what items should be included in the appraisal thereof.)

_____
Forest fire control in the Lake States. L.S. Misc. Report 32, 11 pp., illus. (Processed.) Oct. 1954.

(Outlines the development of forest fire control in the Lake States, the progress made, and the problems remaining.)

_____, and Olsen, L. P.
Fire occurrence: Periodicity of good and bad years. L.S. Tech. Note 419, 2 pp., illus. (Processed.) July 1954.

(Analysis of 39-year record of fire occurrence in the Lake States indicates the possibility of an 8-year cycle. Indicates the number of fires to be expected during the next 8 years if fire occurrence follows the same pattern.)

b. Insects

Batzer, H. O., and Benjamin, D. M.
Cold temperature tolerance of the European pine shoot moth (Rhyacionia buoliana (Schiff.)) in lower Michigan. Jour. Econ. Ent. 47 (5): 801-803. Oct. 1954.

(No significant difference in cold hardiness was found, in laboratory exposure tests, between larvae from Cadillac and Lansing, Michigan. It appears the lethal low temperature lies between -25° and -30° C. (-13° to -18° F.).)

Beckwith, L. C.
Larch sawfly conditions in the Lake States in 1953. L.S. Misc. Report 25, 6 pp., illus. (Processed.) Jan. 1954.

(A report on aerial and ground surveys in the tamarack type in the Lake States.)

_____, and MacAloney, H. J.
The forest insect situation in the Lake States in 1953. L.S. Misc. Report 28, 7 pp., illus. (Processed.) 1954.

(A coordinated statement of the situation prepared from reports by cooperating federal, state, and private agencies as well as from the Station surveys.)

Benjamin, D. M.
The jack-pine budworm in Michigan, 1953. L.S. Tech. Note 414, 1 p. (Processed.) Apr. 1954.

(No delayed mortality of jack pine was apparent after 2 years of heavy defoliation. Little additional tree mortality was predicted if budworm populations continued to decline.)

_____, and Drooz, A. T.
Parasites affecting the jack-pine budworm in Michigan. Jour. Econ. Ent. 47 (4): 588-590. Aug. 1954.

(A brief account of the role of parasites in jack-pine budworm infestations in Michigan. Two species, Itoplectis conquisitor and Apanteles fumiferanae, were the most important.)

c. Diseases

(None)

d. Wildlife

Krefting, L. W., and Stoeckeler, J. H.
Effect of simulated snowshoe hare and deer damage on some conifers planted in the Lake States. L.S. Tech. Note 413, 2 pp., illus. (Processed.) Jan. 1954.

(Results 6 years after treatment show that the removal of 1 inch of the terminal growth by single or repeated clippings reduces survival and height growth of planted stock. Resistance to damage varied by species and can be attributed to the inherent ability of each species to produce new leaders. Species tested were red pine, jack pine, white pine, and white spruce.)

Smith, Lloyd L., Jr., and Krefting, L. W.
Fluctuations in production and abundance of commercial species in the Red Lakes, Minnesota, with special reference to changes in the walleye population. Transactions of Amer. Fisheries Soc. 83: 131-160, illus. 1954.

(Fluctuations in abundance of the important species have been studied for the 24-year period, 1930 to 1953. Wide variations were noted but, although there has been a large increase in fishing efforts during the past few years, no trends have developed. Implications for management include provision of adequate prediction of abundance, and adjustment of fishing practices on an annual basis to make greatest use of available stock.)

Keener, John, and Stoeckeler, J. H.
Logging operations provide winter feed for deer. L.S. Tech. Note 421, 1 p. (Processed.) Oct. 1954.
(Observations indicate that winter logging operations, particularly in the hardwood-hemlock type and in white-cedar swamps, attract large numbers of deer.)

Forest Survey

Chase, C. D., and Horn, A. G.
Timber resources of Dickinson and Iron Counties, Michigan, 1952. Mich. Cons. Dept., 38 pp., illus. (Processed.) 1954.
(Presents forest areas, timber volumes, growth, allowable cut, and drain by species and kinds of timber.)

Cunningham, R. N.
Can Wisconsin become self-sufficient in pulpwood? L.S. Tech. Note 410, 2 pp. (Processed.) Jan. 1954.
(The answer is affirmative only if more hardwoods can be utilized. The Note explains why.)

Dickerman, M. B.
The changing forests of the Lake and Central States region. L.S. Misc. Report 31, 10 pp. (Processed.) Oct. 1954.
(Reviews briefly the trends in: forest composition, volume and quality; ownership; and reforestation. Discusses some special problems.)

Gevorkiantz, S. R.
Problems in forest inventory from the forester's point of view. Iowa State College Press, Statistics and Mathematics in Biology, pp. 251-262. 1954.
(Discusses the purpose of forest surveys, problems in estimation of forest areas, volume and growth, and the need for further research along these lines.)

Guilkey, Paul C.
*Growth versus allowable cut. Jour. For. 52 (4): 257-259. Apr. 1954.
(Allowable cut explains a number of things not expressed by growth estimates alone.)

_____, Granum, B., and Cunningham, R. N.
Forest statistics for Minnesota, 1953. L.S. Sta. Paper 31, 36 pp., illus. Nov. 1954.
(Presents basic statistics for Minnesota on forest areas, timber volumes, forest ownership, growth, allowable cut, and timber drain found as a result of the forest survey initiated in 1946 and completed in 1953. Some generalized comparisons are made of current forest conditions and those found during the previous survey in 1936.)

Heinselman, M. L.
The extent of natural conversion to other species in the Lake States aspen-birch type. Jour. For. 52 (10): 737-738. Oct. 1954.
(Reports on a study, based on forest survey data, which indicates that successional changes may convert approximately 47 percent of the present Lake States aspen area to northern hardwoods, balsam fir, and other species within the next 30 to 60 years.)

Horn, A. G.
Aspen makes up nearly one-half of 1953 pulpwood cut in Lake States. L.S. Tech. Note 418, 2 pp. (Processed.) Apr. 1954.
(Shows production by species in Minn., Wis., and Mich.; also imports from Canada and Western States and movement between states in the region. Eighth of an annual series.)

_____
Commodity drain from forests of the Lake States, 1952. L.S. Misc. Report 26, 25 pp. (Processed.) Apr. 1954.
(Shows the volume of merchantable timber cut from Minn., Wis., and Mich., by species and product.)

_____
*Most forest wood goes to pulping. Menominee Herald Leader, p. 18, Sept. 16, 1954.
(Describes growth of Lake States pulpwood industry, and increased production of wood through use of aspen and dense hardwood species.)

_____
Production indexes for rough forest products--Lake States. L.S. Tech. Note 415, 2 pp., illus. (Processed.) Apr. 1954.
(Shows annual production of major saw-log and cordwood products for 1946-52 and averages for 1936-45 years combined; also index of production with 1936-45 average as a base.)

Johnson, H., Horn, A. G., and Guilkey, P. C.
The forest resource of Becker County. Iron Range Res. and Rehab., 61 pp., illus. 1954.
(Forest areas, timber volumes, growth, allowable cut, and drain for Becker County, Minn.)

_____, _____, and _____
The forest resource of Lake of the Woods County. Iron Range Res. and Rehab., 61 pp., illus. 1954.
(Another in county series.)

_____, _____, and _____
The forest resource of the Red River Valley, Minnesota. Iron Range Res. and Rehab., 57 pp., illus. 1954.
(Forest areas, timber volumes, growth, allowable cut, and drain for the Minnesota counties of Roseau, Kittson, Marshall, Pennington, Red Lake, Polk, Norman, Mahnomen, and Clay.)

Wisconsin Conservation Department and Lake States Forest Experiment Station
Forest resources of Waupaca County, Wisconsin. Wis. Cons. Dept., 37 pp., illus. (Processed.) 1954.
(Presents forest areas, timber volumes, growth, drain, and allowable cut in the county, and the results of a reproduction survey in Waupaca and adjacent counties.)

_____ and _____
Forest resources of Waushara County, Wisconsin. Wis. Cons. Dept., 36 pp., illus. (Processed.) 1954.
(Another in county series.)

Forest Economics

Stump, W. G., Arend, J. L., and Ralston, R. A.
*The log cutter--a weak link in quality control. Natl. Hardwood Mag. 27 (11): 131. Dec. 1953.
(Failure to cut logs for maximum grade penalizes everyone concerned with wood products, except the log cutters who make the mistakes. In a study on one white oak logging job of 30 M bd. ft. in southern Michigan, it was found that 14 percent of the trees were miscut for grade. This amounted to 14 percent of the logs and 24 percent of the total volume. The volume of No. 1 logs would have been increased from 34 to 50 percent if they had been cut correctly.)

Conover, D. F.
*Planted jack pine yield early returns. Blackduck American, May 13, 1954, illus.
(Describes partial cut of pulpwood, small posts and fuelwood from an 18-year-old jack pine plantation, which yielded products worth $30 per acre at the roadside.)

Engle, LaMont G.
Some cost aspects of pruning red pine. Mich. Acad. Sci., Arts, and Letters. Papers 39: 151-157. 1954. (1953 meeting.)
(The time to prune red pine to a height of 17 feet varies considerably, depending mainly on size of limbs and number of whorls, but averages about 10 minutes per tree. The expense of pruning increases rapidly with height. Cost per lineal foot from 12 to 17 feet is twice that up to 8.5 feet.)

General

Arend, J. L., Smith, R. N., and Ralston, R. A.
Tests of a portable wood chipper. L.S. Sta. Paper 30, 37 pp., illus. (Processed.) Jan. 1954.
(Chipping performance tests were made, using oak, aspen, and pine wood, to determine production rates, operational costs, general adaptability, and portability of the chipper for slash and brush disposal and utilization operations. Two variations of the same model chipper, differing mainly in number of knives, cutting speed, and size of feeding hopper, were used. A 31-hp. motor was used on both models.)

Dickerman, M. B.
*Thirty years of federal forest research in Minnesota. Univ. of Minn. School of For. Bul.: Forestry in Minnesota, Past, Present, and Future, pp. 54-62. 1954.
(The history of the Lake States Station and its program; future research needs.)

---

*Forest research--the key to progress. Proc. Wis. Silver Anniversary Forestry Conf., pp. 141-145, 1954. Also Lake States Timber Dig. 7 (11): 1, 3-4, illus., Apr. 1954; and Wis. Cons. Bul. 19 (6): 12-14, June 1954.
(Discusses the opportunities through which research workers can find ways of increasing timber productivity.)

Rees, L. W., and Neetzel, J. R.
*Cold-soaking treatment increases service life of fence posts. Minn. Farm & Home Sci. 11 (3): 10-11, illus. May 1954.
(Presents results of 10-year field tests for 7 species of fence posts treated with a 5-percent pentachlorophyl by the cold-soak method. The jack pines were all in excellent condition after 10 years. Most of the treated oak and ash posts also remained sound. Quite a few failures were noted in paper birch. After 10-year tests nearly a third of the treated cottonwood and aspen posts had failed and many others were in poor condition.)

Stoeckeler, Joseph H.
*Research in the Lake States. Ames Forester, pp. 19-22, illus. 1954.
(Discusses some of the forest management problems and research studies carried on, with special reference to the work of the Northern Lakes Research Center.)